IN TWO SECTIONS—SECTION TWO

TRANSACTIONS

of The American Society of Mechanical Engineers

SOCIETY RECORDS—Part III

(Including Indexes to Publications)

[Part I of Society Records for the year 1936 (containing Council and Committee Personnel and other general information) was issued as Section Two of the Transactions for February, 1936, and Part II (Memorial Notices), August, 1936.]

JANUARY, 1937

VOL. 59, NO. 1

Published by The American Society of Mechanical Engineers

TRANSACTIONS

of The American Society of Mechanical Engineers

Published on the tenth of every month, except March, June, September, and December

Publication Office, 20th and Northampton Streets, Easton, Pa.
Editorial Department at the Headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y.

Includes Aeronautical Engineering

Entered as second-class matter March 2, 1928, at the Post Office at Easton, Pa., under the act of August 24, 1912. Price $1.50 a copy, $12.00 a year; to members and affiliates, $1.00 a copy, $7.50 a year. Changes of address must be received two weeks before they are to be effective on our mailing list. Please send old, as well as new, address.

Depositories for A.S.M.E. Transactions in the United States

BOUND copies of the complete Transactions of The American Society of Mechanical Engineers will be found in the libraries in the United States and other countries which are listed on the following pages.

Alabama

Auburn........ Engineering Library, Alabama Poly. Inst.
Birmingham...... Public Library
University....... Library, University of Alabama

Arkansas

Fayetteville...... Engineering Library, Arkansas University

California

Berkeley......... Library, University of California
Long Beach...... Public Library
Los Angeles...... Public Library
University of Southern California
Oakland......... Oakland City Library
Teachers' Professional Library
Pasadena........ Library, California Institute of Technology
Santa Clara...... Library, University of Santa Clara
San Diego....... Public Library
San Francisco.... Public Library (Civic Center)
Engineers Club of San Francisco
Mechanics Institute
Stanford Univ.... Library, Stanford University

Colorado

Boulder.......... Library, University of Colorado
Denver.......... Public Library
Fort Collins...... Colorado State Agricultural College

Connecticut

Bridgeport....... Public Library
Hartford......... Public Library
New Haven...... Public Library and Yale University
Waterbury....... Silas Bronson Library

Delaware

Newark.......... University of Delaware
Wilmington...... Wilmington Free Institute

District of Columbia

Washington...... Scientific Library, U. S. Patent Office
Library of Congress
Bureau of Standards Library
George Washington and Catholic Universities

Florida

Gainesville....... University of Florida
Jacksonville...... Free Public Library
Miami........... Public Library
Tampa.......... Public Library

Georgia

Atlanta.......... Carnegie Public Library
Georgia School of Technology
Savannah........ Public Library

Idaho

Moscow......... University of Idaho

Illinois

Chicago.......... John Crerar Library
Western Society of Engineers
Lewis Institute of Technology
Library, Armour Institute of Technology
Public Library of Chicago
Evanston........ Northwestern University
Moline.......... Public Library
Urbana.......... University of Illinois

Indiana

Evansville....... Public Library
Fort Wayne...... Public Library
Indianapolis...... Public Library and Indiana State Library
Notre Dame..... Library, University of Notre Dame
Terre Haute...... Rose Polytechnic Institute
West Lafayette... Library, Purdue University

Iowa

Ames............ Iowa State College
Des Moines...... Public Library
Iowa City........ State University of Iowa

Kansas

Kansas City...... Public Library, Huron Park
Lawrence........ Library, University of Kansas
Manhattan....... Kansas State Agricultural College
Wichita.......... Wichita City Library

Kentucky

Lexington........ University of Kentucky
Louisville........ Speed Scientific School
University of Louisville

Louisiana

Baton Rouge..... Louisana State University
New Orleans..... Howard Memorial Library
Louisiana Engineering Society
Public Library
Tulane University

Maine

Orono........... University of Maine

Maryland

Annapolis........ United States Naval Academy
Baltimore........ Johns Hopkins University
Engineers Club of Baltimore
Public Library

Massachusetts

Boston.......... Engineering Societies of New England
Northeastern University
Boston Public Library
Cambridge....... Harvard University (Engineering Library)
Massachusetts Institute of Technology
Fall River....... Public Library
Lynn............ Free Public Library
New Bedford..... Free Public Library
Springfield....... Springfield City Library
Tufts College..... Tufts College
Worcester........ Worcester Polytechnic Institute
Free Public Library

Michigan

Ann Arbor....... University of Michigan
Detroit.......... Public Library
Cass Technical High School
Highland Park Public Library
University of Detroit
East Lansing..... Michigan State College
Flint............ Public Library
Grand Rapids.... Public Library
Houghton........ Michigan College of Mining & Technology
Jackson.......... Public Library

Minnesota

Duluth.......... Public Library
Minneapolis...... University of Minnesota
Minneapolis Public Library (Engineering and Circulating Libraries)
St. Paul.......... James Jerome Hill Reference Library

Mississippi

State College..... Mississippi State College

Missouri

Columbia........ University of Missouri
Kansas City..... Public Library
Rolla............ Missouri School of Mines and Metallurgy
St. Louis......... Engineers Club of St. Louis
Public Library
Washington University
Mercantile Library

Montana

Bozeman........ Montana State College

Nebraska

Lincoln.......... University of Nebraska
Omaha.......... Public Library

Nevada

Reno............ University of Nevada Library

New Hampshire

Durham.........University of New Hampshire

New Jersey

Bayonne.........Free Public Library
Camden.........Free Public Library
Elizabeth........Free Public Library
Hoboken.........Stevens Institute of Technology
Jersey City......Free Public Library
Newark..........Newark College of Engineering
Free Public Library
New Brunswick..Rutgers University
Paterson.........Free Public Library
Princeton........Princeton University
Trenton.........Free Public Library

New Mexico

Albuquerque.....University of New Mexico

New York

Albany..........New York State Library
Brooklyn........Polytechnic Institute
Pratt Institute
Brooklyn Public Library
Buffalo..........The Grosvenor Library
Engineering Society of Buffalo
Buffalo Public Library
Ithaca...........Cornell University
Jamaica, L. I.....Queens Borough Public Library
New York.......Engineering Societies Library
Public Library
College of the City of New York
Cooper Union
Columbia University
New York Museum of Science and Industry
New York University Library
Potsdam.........Clarkson College of Technology
Rochester........Rochester Engineering Society
Schenectady......Union College
Syracuse.........Syracuse University
Public Library
Troy............Rensselaer Polytechnic Institute
Utica............Public Library
Yonkers.........Public Library

North Carolina

Chapel Hill......University of North Carolina
Durham.........Duke University
Raleigh..........North Carolina State College

North Dakota

Fargo...........North Dakota State Agricultural College
Grand Forks.....University of North Dakota

Ohio

Ada.............Ohio Northern University
Akron...........Public Library
University of Akron
Canton..........Public Library
Cincinnati.......University of Cincinnati
Public Library
Engineers Club of Cincinnati
Cleveland........Public Library
Case School of Applied Science
Cleveland Engineering Society
Columbus........State of Ohio Library
Public Library
Ohio State University
Dayton..........Engineers Club of Dayton
Toledo..........Public Library
University of Toledo
Youngstown......Public Library

Oklahoma

Norman.........Oklahoma University
Oklahoma City...Public Library
Stillwater........Oklahoma A. & M. College
Tulsa............Public Library

Oregon

Corvallis.........Oregon State Agricultural College
Portland.........Portland Library Association

Pennsylvania

Allentown........Free Library
Bethlehem.......Lehigh University
Easton..........Public Library
Lafayette College
Erie.............Public Library
Lewisburg.......Bucknell University
Philadelphia......Engineers Club
Drexel Institute
The Free Library
University of Pennsylvania
Franklin Institute
Pittsburgh.......University of Pittsburgh
Engineers' Society of Western Pennsylvania
Carnegie Institute of Technology
Carnegie Library (Schenley Park)
Carnegie Free Library of Allegheny
Reading.........Public Library
Scranton.........Public Library
State College.....Pennsylvania State College
Swarthmore......Swarthmore College
Villanova........Villanova College
Wilkes-Barre.....Public Library

Rhode Island

Kingston........Rhode Island State College
Providence.......Brown University
Providence Engineering Society
Public Library

South Carolina

Clemson College..Library, Clemson College

South Dakota

Brookings........South Dakota State College

Tennessee

Kingsport........Public Library
Knoxville........University of Tennessee
Memphis........Goodwin Institute
Nashville........Vanderbilt University

Texas

Austin...........University of Texas
College Station...Agricultural & Mechanical College of Texas
Dallas...........Public Library
Southern Methodist University
El Paso..........Public Library
Fort Worth......Carnegie Public Library
Houston.........Rice Institute
Public Library
Lubbock.........Texas Technological College
San Antonio......Carnegie Library

Utah

Salt Lake City...University of Utah
Public Library

Vermont

Burlington.......University of Vermont

Virginia

Blacksburg.......Virginia Polytechnic Institute
Charlottesville....University of Virginia
Norfolk..........Public Library
Richmond.......Virginia State Library

Washington

Pullman.........State College of Washington
Seattle..........Public Library
Engineers Club
University of Washington
Spokane.........Public Library
Tacoma.........Public Library

West Virginia

Morgantown.....West Virginia University

Wisconsin

Madison.........Library, University of Wisconsin
Milwaukee.......Public Library
Vocational School Library
Marquette University

Wyoming

Laramie.........Wyoming University

Depositories for A.S.M.E. Transactions Outside the United States

Argentine

Buenos Aires.....Biblioteca de la Sociedad Cientifica

Australia

Adelaide.........Public Library of Adelaide
Melbourne.......Public Library of Victoria
Perth............University of Western Australia Library
Sydney..........Public Library, N. S. W., Sydney

Belgium

Louvain.........University of Louvain

Brazil

Rio de Janeiro....Bibliotheca da Escola Polytechnica
Bibliotheca Nacional
Sao Paulo........Bibliotheca da Escola Polytechnica

Canada

Montreal........McGill University
Engineering Institute of Canada
Toronto.........University of Toronto, Library

Chile

Santiago.........Universidad de Chile, Facultad de Ciencias Fisicas y Matematicas (Engrg. School)

China

Peiping..........College of Technology of Peiping University

Cuba

Havana..........Cuban Society of Engineers

Czechoslovakia

Prague..........Masarykova Akademie Prace
Society of Czechoslovak Engineers

Danzig Free City........Bibliothek der Technischen Hochschule

Denmark

Copenhagen......The Royal Technical College

England

Birmingham......Birmingham Public Libraries
Bristol...........University of Bristol
Cambridge.......University of Cambridge
Leeds...........University of Leeds
Liverpool........Public Library of Liverpool
Liverpool Engineering Society
London..........City & Guild Engineering College
Institution of Automobile Engineers
Institution of Mechanical Engineers
Institution of Civil Engineers
Institution of Electrical Engineers
The Junior Institution of Engineers
The Royal Aeronautical Society
Manchester......Manchester Public Libraries (Reference Library)
Oxford..........University of Oxford
Newcastle-upon-Tyne..........The North East Coast Institution of Engineers and Shipbuilders
Sheffield.........Sheffield Public Libraries

Wales

Cardiff..........Cardiff Public Library

France

Lyons...........University of Lyons
Paris............École Nationale des Arts et Metiers
École Nationale Supérieure de L'Aeronautique
École Centrale des Arts et Manufactures de Paris
Société des Ingénieurs Civils de France

Germany

Berlin...........Verein deutscher Ingenieure
Bibliothek der Technischen Hochschule
Breslau..........Bibliothek der Technischen Hochschule
Cologne (Köln)...Universitäts- und Stadtbibliothek

Germany (Continued)

Dresden.........Bibliothek der Technischen Hochschule
Düsseldorf.......Bücherei des Vereines deutscher Eisenhüttenleute
Frankfort........Technische Zentralbibliothek
Hamburg........Bibliothek der Technischen Staatslehranstalten
Hanover.........Bibliothek der Technischen Hochschule
Karlsruhe.......Bibliothek der Technischen Hochschule
Leipsic..........Stadtbibliothek
Munich..........Bibliothek der Technischen Hochschule
Bibliothek des Deutschen Museums
Stuttgart........Bibliothek der Technischen Hochschule

Hawaii

Honolulu........University of Hawaii Library

Holland

Amsterdam......Koninklijke Akademie von Wetenschappen
Delft............Bibliotheek der Technische Hoogeschool
The Hague.......Koninklijk Instituut van Ingenieurs
Rotterdam.......Nationaal Technisch Scheepvaartkundig Institut

India

Bangalore........Mysore Engineers Association
Calcutta.........Bengal Engineering College
Poona...........Poona College of Engineering
Rangoon.........University of Rangoon

Ireland

Belfast..........Queen's University of Belfast

Italy

Milan...........Biblioteca della R. Scuola d'Ingegneria
Comitato Autonomo per l'Esame della Invenzioni
Naples..........Biblioteca della R. Scuola d'Ingegneria
Rome...........Biblioteca della R. Scuola d'Ingegneria
Consiglio Nazionale delle Ricerche presso il Ministero della Educazione Nazionale
Turin...........Biblioteca della R. Scuola d'Ingegneria

Japan

Kobe............Kobe Technical College
Tokyo...........Imperial University Library
The Society of Mechanical Engineers
Yokohama.......Library of Yokohama

Mexico

Mexico City......Asociacion de Ingenieros y Arquitectos de Mexico
Library of the Escuela de Ingenieros Mecanicos y Electricistas

Norway

Oslo.............Den Polytekniske Forening

Poland

Warsaw.........Bibljoteka Publicazna

Puerto Rico

Mayaguez.......University of Puerto Rico

Portugal

Lisbon...........Institute Superior Technico

Roumania

Bucharest........Scoala Polytechnica din Bucharest

Scotland

Glasgow.........Royal Technical College
Mitchell Library

South Africa

Cape Town......University of Cape Town
Johannesburg....South African Institute of Engineers

Sweden

Stockholm....... Kungl. Tekniska Hogskolan
Svenska Teknologföreninger
Gothenburg...... Chalmers Tekniska Institut

Switzerland

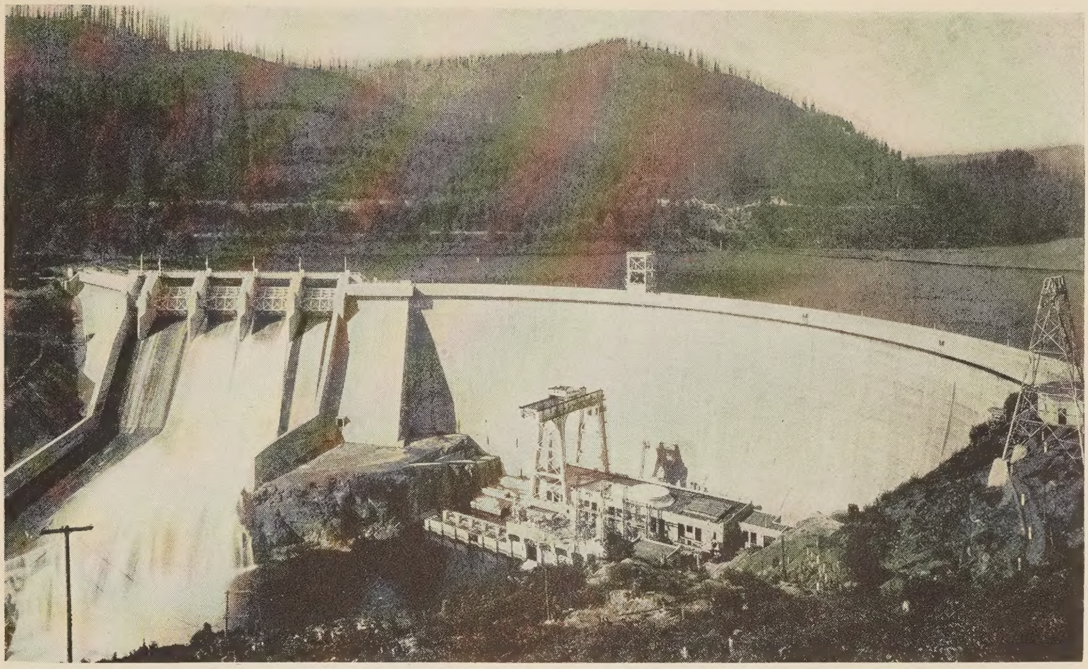
Zurich........... Bibliothek der Eidg. Technischen Hochschule

Turkey

Istanbul......... Robert College

U.S.S.R.

Kharkov......... Supreme Economic Council of Ukraine
Leningrad........ Leningrad Polytechnic Institute
Moscow.......... Supreme Council of National Economy
Tomsk.......... Tomsk Polytechnic Institute



Ariel Hydroelectric Development on the Lewis River in Washington
(An arch dam with a spillway thrust block and an outdoor station.)

Hydroelectric Practice in the United States

By A. C. CLOGHER,[1] NEW YORK, N. Y.

The author discusses hydroelectric development in the United States from the earliest installation up to the present time. He points out that hydroelectric plants added to large power systems in this country during the past 15 years have been constructed because they have appeared to be more economical than thermal-electric plants for adding the same number of kilowatts to the same power system, excepting the construction of hydro-electric plants in those sections of the country where hydroelectric plants can compete with thermal electric plants in producing power and energy at the load factor of the utility loads. The author also discusses the design of equipment used in the older and in the more recent hydroelectric installations. The paper includes a list of the major hydroelectric installations in the United States together with their present rating and ultimate capacity.

DESIGN practice in the United States in respect to hydroelectric developments has been influenced to a considerable extent by a number of practical factors in addition to the technical improvements which have been made in the design of the plants and the equipment contained in them.

[1] Consulting Engineer, Ebasco Services Incorporated. Mr. Clogher was graduated from Worcester Polytechnic Institute in 1905. He became associated with H. L. Cooper in the design of the Holtwood hydroelectric development and later with the engineering firm of Viele, Blackwell and Buck on the construction of the Schagticoke hydroelectric development. In 1909 he became associated with the Electric Bond and Share Company as hydraulic engineer, and later became consulting engineer of its subsidiary, which position he now holds.

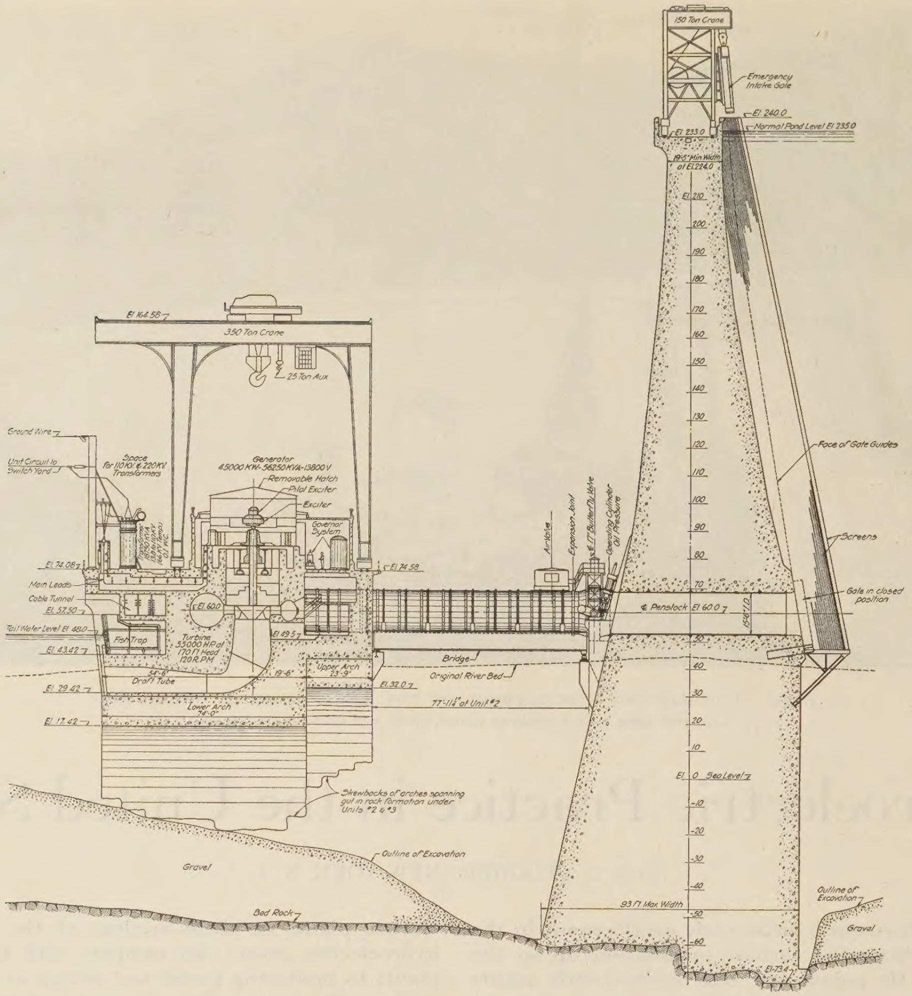
Contributed by the Hydraulic Division and presented at the Niagara Falls Meeting of The American Society of Mechanical Engineers, held at Niagara Falls, N. Y., September 17 to 19, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, N. Y., and will be accepted until April 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

Prior to 1910 nearly all of the hydroelectric developments built served individual limited loads and areas. In some cases a single hydro plant was the sole source of power for a considerable community. The loads were small and the reliability of long-distance transmission lines had yet to be proved. The financial resources of many of these early utilities were limited. All these factors had to be taken into consideration by the designer, on top of solving the problems presented by a new kind of construction. Many of these early generating stations were small, and were without much reservoir capacity, being what is now termed "run-of-river" stations. Some of them were promoted and built as separate and independent entities, the expectation being that they would produce and sell power on a wholesale basis to others for resale to the ultimate consumer.

By 1910 the business of producing, distributing, and selling residential, commercial, and industrial electric service was fast becoming crystallized into the form which has since become the present-day public-utility operating company. The twenty years immediately following 1910 saw a great growth in load, and an equally great change in the methods used in producing and distributing power.



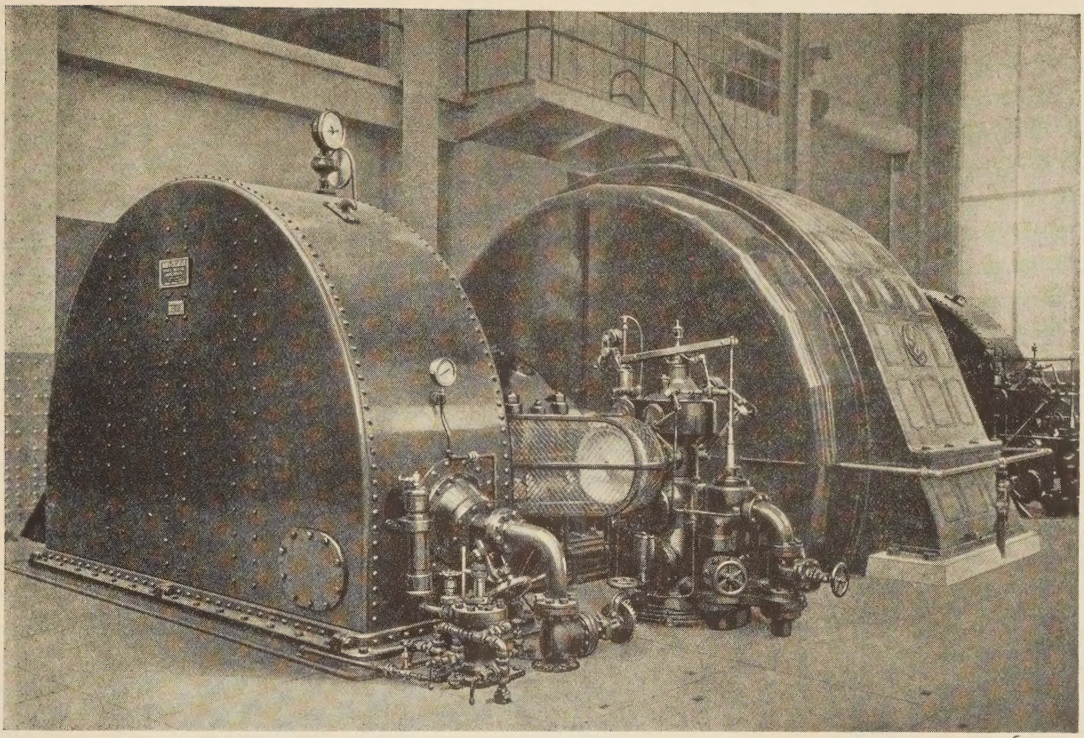
SECTION THROUGH THE DEEPEST PORTION OF THE DAM AND POWER HOUSE OF THE ARIEL DEVELOPMENT

The consolidation of operating properties was made practicable by two major savings in cost. It improved the credit of the utilities and made possible more economical financing, and substantial operating economies were secured by consolidation, especially through diversity in load and power-production sources. These changes removed some of the limitations which had been hampering the engineers, and the diversified uses of the power stations enlarged the opportunities for skill and ingenuity on the part of the power-plant designers. Almost all of the power plants constructed between 1910 and 1930 were built or caused to be built by the operating utility companies for the purpose of supplying particular sections of their own requirements for power and energy.

Thus today in the modern power system with both hydro and thermal generating stations, the run-of-river hydro plants and the thermal plants probably will be found on the base load, and the hydroelectric plants with storage capacity sufficient for peak-load operation, or with storage capacity for stream-flow regulation occupying the position on the load curve for which they are best suited. Such a power system is operated as an entity with the various generating stations treated as parts with diverse characteristics to be utilized to the best advantage to produce the most power for the least cost. The needs of the unified system has had a controlling influence on the general design, and on many of the details. It has been possible to utilize to advantage many marginal hydro sites with special characteristics which fit specific needs of the system to be served, which otherwise would have been uneconomical. The plants have been made to fit the particular load to be carried; the load has not been fitted to the power plants.

A substantial number of the early run-of-river plants are still in service. It is true that some of the earlier generating stations were not adapted for modern use, or were found to be costly to operate. In general, such obsolete stations have been scrapped. But a great many of the early power developments are still giving good service in their assigned places in the power-producing facilities of the utilities of which they are now a part. Their retention in useful and profitable service is a distinct economic gain, which would not be possible if diversified loads and generating stations had not been unified.

In the early years of this century, hydroelectric plants were generally looked upon as competitive substitutes for thermal electric plants. But after 1910, engineers began to realize that a combination of thermal and hydro generating stations had positive operating advantages, and often could produce the power required for less cost than could be done by hydro alone or by steam alone. As power systems grew in size, as larger developments became possible, and as more generating stations



THE 40,000-HP TWIN OVERHUNG IMPULSE UNIT AND GOVERNOR AT THE BALCH DEVELOPMENT ON THE KINGS RIVER IN CALIFORNIA

were interconnected, the possible combinations became more numerous, and the economy of constructing for specific and special purposes became greater. Some areas are still predominated by hydro; others are served entirely by steam. But in many others combinations are to be found with the hydros carrying the bulk of the load when water is abundant, and being shifted to peak-load service during the dry season when the steam-electric plants pick up the base load.

In the modern power system, the necessary reserves held against machine and transmission outage often are provided by extra units in the hydro stations, supported by stored water held to operate the reserve units when needed.

In another sense, the hydro and thermal plants are still in keen competition with each other. When a new hydroelectric generating station is projected, it is necessary to first prove that it will supply or make available the required power and energy for less cost than would a thermal-electric installation. In making such comparisons all the diverse factors must be considered and equated. It is often necessary, in complex power systems, to rearrange on paper the entire operating procedure including the power-plant loadings, and compare the overall results of system operation after the various types of plants are installed. In the past twenty-five years the efficiency of thermal-electric plants has increased greatly, with a consequent reduction in production costs. During the same period, in general the most desirable hydro sites have been developed. These two factors have sharpened the competition so that in most sections of the country the thermal-electric plant has an advantage for high-load-factor operation. The future for hydro developed on an economic basis in competition with other sources of power is probably in the low-load-factor and specialty field.

PLANTS HAVE FEW UNITS

The size of American operating companies and the extensive territory over which their transmission systems extend has resulted in very few of the larger systems having less than five generating stations, and in general, it might be said they have between ten and 30 generating plants tied into the same transmission network.

In addition to this diversity of generating plants, a great majority of the transmission networks are interconnected with other networks at several locations. These interconnections are valuable for maintaining service, for interchanging power and energy, and for providing for emergency service in case of breakdowns at generating stations or at other points.

These conditions account for one striking difference between American and European practice in hydroelectric power-plant general design, that is, the use of large units and of a relatively small number of them in each station. The whole station itself is looked upon as a unit of the producing facilities and this viewpoint has resulted in the construction of several one-unit stations and quite a large number with only two units as the ultimate installation. Physical limitations in the machines themselves are as a rule the reason for more than two units in a generating station.

The flexibility in loading conditions for a large number of stations under the control of one despatcher generally makes it possible to utilize one or two units very effectively. For example, a recently completed one-unit station of approximately 10,000 kw capacity is the ninth generating station and the twenty-ninth generating unit on the system of which it is a part. It can be loaded to the point of maximum efficiency for approximately 20 hr per day in the winter and for approximately 10 hr per day in the summer. Except for a relatively few hours when its maximum-peak capacity is required and a six-weeks' period annually when surplus hydro energy is available, it is operated five and one-half days per week at the maximum-efficiency point for that number of hours for which water is available. High-water sea-

TABLE 1 MAJOR HYDROELECTRIC DEVELOPMENTS[a] IN THE UNITED STATES BUILT SUBSEQUENT TO 1924 AND IN OPERATION OR UNDER CONSTRUCTION IN 1934[b]

Development	River	State	Operating company	Ultimate horsepower	In operation or being installed: Hp	Year of initial operation	Year of completion
North and Middle Atlantic drainage area							
Wyman	Kennebec	Maine	Cen. Maine Power Co.	102,000	68,000	1931	1931
Rumford Falls	Androscoggin	Maine	Rumford Falls Power Co.	42,000	36,000	1903	1926
Gulf Island	Androscoggin	Maine	Cen. Maine Power Co.	27,000	27,000	....	1925
Bonny Eagle and West Buxton	Saco	Maine	Cumberland County Pr & Lt Co.	23,000	23,000	....	1927
Amoskeag	Merrimac	N. H.	Amoskeag Mfg. Co.	.....	33,910	....	....
Comerford (15 Mile Falls)	Connecticut	N. H. and Vt.	Connecticut River Power Co.	215,000	215,000	1930	1930
Bellows Falls	Connecticut	N. H.	Bellows Falls Hydroelec. Corp.	66,000	66,000	1928	1928
Harriman	Deerfield	Vt.	New England Power Co.	60,000	60,000	1924	1925
Cobble Mt.	Westfield Little	Mass.	Turners Falls Pr & Elec. Co.	46,950	46,950	1932	1932
Rocky River	Housatonic	Conn.	Connecticut Lt & Pr Co.	66,000	33,000	1929	1929
E. J. West	Sacandaga	N. Y.	New York Pr & Lt Corp.	51,500	34,300	1930	1930
Spier Falls	Hudson	N. Y.	New York Pr & Lt Corp.	154,000	92,200	1904	1930
Wallenpaupack	Wallenpaupack	Pa.	Pennsylvania Pr & Lt Co.	57,000	57,000	1926	1926
Safe Harbor	Susquehanna	Pa.	Safe Harbor Water Pr Corp.	510,000	255,000	1931	1934
Conowingo	Susquehanna	Md.	Susquehanna Electric Co.	594,000	378,000	1928	1928
South Atlantic and East Gulf of Mexico drainage area							
Reusens	James	Va.	Appalachian Electric Pr Co.	20,200	20,200	1904	1931
High Rock	Yadkin	N. C.	Carolina Alum. Co.	44,100	44,100	1928	1928
Norwood (Tillery)	Yadkin	N. C.	Carolina Pr & Lt Co.	118,900	87,800	1928	1928
Rhodiss	Catawba	N. C.	Duke Power Co.	42,000	42,000	1925	1925
Oxford	Catawba	N. C.	Duke Power Co.	56,000	56,000	1928	1928
Catawba	Catawba	S. C.	Duke Power Co.	86,000	86,000	1925	1925
Cedar Creek	Catawba	S. C.	Duke Power Co.	51,300	51,300	1926	1926
Saluda	Saluda	S. C.	Lexington Water Power Co.	330,000	220,000	1930	1930
Terrora	Tallulah	Ga.	Georgia Power Co.	30,400	30,400	1925	1925
Yonah	Tugalo	Ga.	Georgia Power Co.	42,600	42,600	1925	1925
Bartletts Ferry	Chattahoochee	Ga.	Georgia Power Co.	88,000	66,000	1926	1926
Martin Dam (Cherokee Bluffs)	Tallapoosa	Ala.	Alabama Power Co.	180,000	135,000	1927	1927
Upper Tallassee	Tallapoosa	Ala.	Alabama Power Co.	75,000	50,000	1928	1928
Thurlow (Lower Tallassee)	Tallapoosa	Ala.	Alabama Power Co.	72,000	72,000	1931	1931
Jordan (Lock No. 18)	Coosa	Ala.	Alabama Power Co.	216,000	144,000	1929	1929
Great Lakes drainage area							
Sault Ste. Marie	St. Mary	Mich.	Mich. Northern Power Co.	.....	40,000	....	....
Hardy	Muskegon	Mich.	Consumers Power Co.	40,000	40,000	1931	1931
Hodenpyl	Manistee	Mich.	Consumers Power Co.	24,000	24,000	1925	1925
Rochester No. 5	Genesee	N. Y.	Rochester Gas & Elec. Corp.	54,000	54,000	1917	1928
Soft Maple	Beaver	N. Y.	Northern N. Y. Utilities, Inc.	31,500	21,000	1925	1925
St. Lawrence River drainage area							
Colton (Browns Bridge)	Raquette	N. Y.	St. Lawrence Valley Pr Corp.	37,700	37,700	1919	1928
Upper Mississippi River drainage area							
Chippewa Falls	Chippewa	Wis.	Northern States Pr Co.	30,000	30,000	1928	1928
Prairie Du Sac	Wisconsin	Wis.	Wisconsin Pr & Lt Co.	41,150	41,150	1909	1926
Missouri River drainage area							
Black Eagle	Missouri	Mont.	Montana Power Co.	25,000	25,000	1913	1927
Morony	Missouri	Mont.	Montana Power Co.	62,000	62,000	1930	1930
Fort Peck	Missouri	Mont.	U. S. govt.	532,000	.....	1939	....
Casper Alcova	North Platte	Wyo.	U. S. govt.	42,000	42,000	1936	1940
Osage (Bagnell)	Osage	Mo.	Union Elec Lt & Pr Co.	268,000	201,000	1931	1931
Ohio River drainage area							
Piney	Clarion	Pa.	Clarion River Power Co.	34,000	34,000	1924	1928
Deep Creek	Deep Creek	Md.	Youghiogheny Hydro Elec Corp.	24,000	24,000	1925	1925
Lake Lynn (Cheat Haven)	Cheat	W. Va.	West Penn Power Co.	72,000	72,000	1926	1927
Hawks Nest	New	W. Va.	New Kanawha Power Co.	175,000	140,000	1935	1936
Dix Dam	Dix	Ky.	Kentucky Utilities Co.	32,724	32,724	1925	1925
Ohio Falls	Ohio	Ky.	Louisville Gas & Elec. Co.	135,000	108,000	1928	1928
Waterville	Pigeon	N. C.	Carolina Pr & Lt Co.	147,000	147,000	1930	1930
Norris Dam (Cove Creek)	Clinch	Tenn.	Tenn. Valley Authority	120,000	120,000	1936	1936
Santeetlah	Cheoah	N. C.	Carolina Alum. Co.	66,000	66,000	1927	1927
Cheoah	Little Tenn.	N. C.	Carolina Alum. Co.	96,000	96,000	1918	1925
Calderwood	Little Tenn.	Tenn.	Aluminum Co. of America	168,000	112,000	1930	1930
Blue Ridge	Toccoa	Ga.	Tenn. Elec. Power Co.	26,700	26,700	1931	1931
Wheeler (Dam No. 3)	Tennessee	Ala.	Tenn. Valley Authority	375,000	48,000	1936	....
Wilson Dam (Muscle Shoals)	Tennessee	Ala.	Tenn. Valley Authority	610,000	260,000	1925	1926

sons of the year, low-load seasons, reserve capacity in hydro or thermal plants elsewhere on the same system, and interconnections with other power systems, provide the necessary reserve for maintenance and breakdowns in such a one-unit station. A list of major hydroelectric installations in the United States is given in Table 1. Articles describing some of the plants are listed in the Bibliography at the end of the paper.

Simplicity of Design

Between 1905 and 1915 there was a tendency to standardize hydroelectric plants in their general layout. An even number of units was considered preferable, so as to make a symmetrical plan centering around a central bay which contained two or more exciter units or house turbines together with other auxiliaries, including possibly a multiunit, central oil-pumping system for governors and bearings. At the entrance end there would be provided repair space and miscellaneous small rooms for storage, machine shop, and offices. A prominent feature of such a plan was the switchboard gallery, extending over the auxiliary bay in the center. An extensive electrical bay occupied the whole of the tailrace side of the superstructure (sometimes it was on the opposite side) making a space for generator busses and switch gallery, transformers, high-tension busses, and switches and special rooms for d-c exciter busses and station auxiliary busses. Such a layout was considered the ideal design for hydroelectric installations.

The very large American plants designed in recent years still contain many of the principal features of that ideal plant, due partly to conservatism, due partly to the fact that idealism is a relatively dominant factor in the design of those plants, and due partly to the excellent quality of that conception of a general plan for a large hydroelectric plant.

The competition of thermal plants, the change in service requirements, the use of marginal sites, and the "special-purpose" plants, have directed the trend of design toward simplicity, low construction cost, and low operating expense. It is no longer

TABLE 1 MAJOR HYDROELECTRIC DEVELOPMENTS[a] IN THE UNITED STATES BUILT SUBSEQUENT TO 1924 AND IN OPERATION OR UNDER CONSTRUCTION IN 1934[b] (Continued)

Development	River	State	Operating company	Ultimate horsepower	In operation or being installed: Hp	Year of initial operation	Year of completion
Lower Mississippi River drainage area							
Ozark Beach	White	Mo.	Empire Dist. Elec. Co.	48,000	24,000	1913	1931
Carpenter	Ouachita	Ark.	Arkansas Pr & Lt Co.	118,500	79,000	1931	1932
Gulf of California and lower South Pacific drainage area							
Boulder (Hoover)	Colorado	Ariz. and Nev.	U. S. govt.	1,835,000	515,000	1935	1941
Parker	Colorado	Ariz.	U. S. govt.	160,000	.....	....	....
Verde	Verde	Ariz.	U. S. govt.	21,000	.....	....	....
Horse Mesa	Salt	Ariz.	Salt River Valley Water Users Assoc.	47,180	47,180	1927	1927
Great Basin drainage area							
Cutler	Bear	Utah	Utah Power & Light Có.	43,000	43,000	1927	1927
Upper South Pacific drainage area							
Copoco No. 1	Klamath	Calif.	Calif.-Oregon Power Co.	37,200	37,200	1925	1925
Pit No. 3	Pit	Calif.	Pac. Gas & Elec. Co.	108,580	108,580	1925	1925
Bucks Creek	Bucks Creek	Calif.	Grt. West Power Co. of Calif.	67,024	67,024	1928	1928
Drum	Bear	Calif.	Pac. Gas & Elec. Co.	73,726	73,726	1913	1928
Big Creek No. 1	Big Creek	Calif.	So. Calif. Edison Co., Ltd.	109,920	109,920	1913	1925
Big Creek No. 2	Big Creek	Calif.	So. Calif. Edison Co., Ltd.	88,470	88,470	1913	1925
Big Creek No. 2*a*	Big Creek	Calif.	So. Calif. Edison Co., Ltd.	124,665	124,665	1928	1928
Big Creek No. 8	Big Creek	Calif.	So. Calif. Edison Co., Ltd.	77,750	77,750	1921	1929
Balch	San Joaquin	Calif.	San Joaquin Lt & Pr Corp.	176,944	44,236	1927	1927
Exchequer	Merced	Calif.	Merced Irrig. Dist.	54,000	42,000	1926	1926
Mocassin	Tuolumne	Calif.	Hetch Hetchy Water Supply	120,000	100,000	1925	1925
Don Pedro	Tuolumne	Calif.	Turlock & Modesto Irrig. Dist.	70,000	41,100	1923	1928
Stanislaus	Stanislaus	Calif.	Pac. Gas & Elec. Co.	45,576	45,576	1908	1908
Melones	Stanislaus	Calif.	Pac. Gas & Elec. Co.	36,193	36,193	1927	1927
Tiger Creek	Mokelumne	Calif.	Pac. Gas & Elec. Co.	80,430	80,430	1931	1931
Electra	Mokelumne	Calif.	Pac. Gas & Elec. Co.	75,000	26,810	1902	....
Pardee	Mokelumne	Calif.	East Bay Municipal Utility Dist. (Oakland)	20,000	20,000	1930	1930
San Francisquito No. 1	Los Angeles Aqueduct	Calif.	City of Los Angeles	96,200	96,200	1917	1928
San Francisquito No. 2	Los Angeles Aqueduct	Calif.	City of Los Angeles	62,000	62,000	1920	1932
Lower North Pacific drainage area							
Diablo	Skagit	Wash.	City of Seattle	320,000	166,000	1936	1936
Gorge	Skagit	Wash.	City of Seattle	320,000	78,000	1924	1928
Baker River	Baker	Wash.	Puget Sound Pr & Lt Co.	80,429	53,619	1925	....
Cedar Falls	Cedar	Wash.	City of Seattle	56,800	56,800	1904	1929
Electron	Pyallup	Wash.	Puget Sound Pr & Lt Co.	30,161	30,161	1904	1929
Cushman No. 1	Skokomish-N. Fk	Wash.	City of Tacoma	50,000	50,000	1926	1926
Cushman No. 2	Skokomish-N. Fk	Wash.	City of Tacoma	112,500	75,000	1931	1931
Lake Chelan	Chelan	Wash.	Chelan Electric Co.	136,000	68,000	1927	1928
Rock Island	Columbia	Wash.	Puget Sound Pr & Lt Co.	210,000	84,000	1933	1933
American Falls	Snake	Idaho	Idaho Power Co.	41,500	41,500	1912	1927
Bonneville	Columbia	Oreg.	U. S. govt.	688,000	114,600	1938	....
Oak Grove *P*	Clackamas	Oreg.	Portland Gen. Elec. Co.	102,546	50,940	1924	1931
Ariel	Lewis	Wash.	Inland Pr & Lt Co.	126,000	63,000	1931	1931
Prospect No. 2	Rogue	Oreg.	Calif.-Oregon Power Co.	70,200	46,800	1928	1928

[a] Ultimate capacity more than 20,000 hp.
[b] Data in this table taken from Table 11 in "A Survey of Hydroelectric Developments," *Electrical Engineering*, vol. 53, 1931, p. 988 and p. 1086. (Table given on pp. 1090–1093.)

necessary to have each plant a self-contained unit, as spare equipment in other plants is available in case of breakdown.

Where simplicity is the dominant note in the design reliability must be secured by the greatest possible perfection of every detail. Electrical equipment is now so reliable that it is not necessary to provide spare exciters for the generators. American engineers are now conceiving of hydroelectric units, and in some cases of hydroelectric plants, as being only as reliable as their weakest link. The design problem, is therefore, to provide strength in every link rather than to provide extra or alternate links.

Dams

The gravity-type concrete dam with the spillway controlled by gates and located near the center of the structure, and discharging into the original river channel at the downstream toe of the dam, is a very common type of dam. Protection of the river bed rock formation was entirely neglected in the early projects but it is now almost universal practice to provide protection against the erosion which might be caused by the discharge from spillways.

The single-arch dam has been given increased attention during the past 15 years and it seems likely that this type of dam will be more widely used in the future. Improvements in design, corroborated by careful laboratory tests, new methods of precooling, closing, and grouting, together with greater certainty in the quality of our concrete masonry, have shown that the single-arch dam, in suitable locations, can effect very considerable savings in cost. Several successfully completed and operating dams of this type, equipped with gates on the spillway crest and located in the center of the arch, have demonstrated that neither favorable topography for a side channel spillway nor tunnels are necessary for the discharge of flood waters in the more ordinary sized structures.

Artificial cooling of the concrete, first successfully practiced on the Ariel arch dam in Washington, avoids any handicap to the single-arch dam on account of speed of construction.

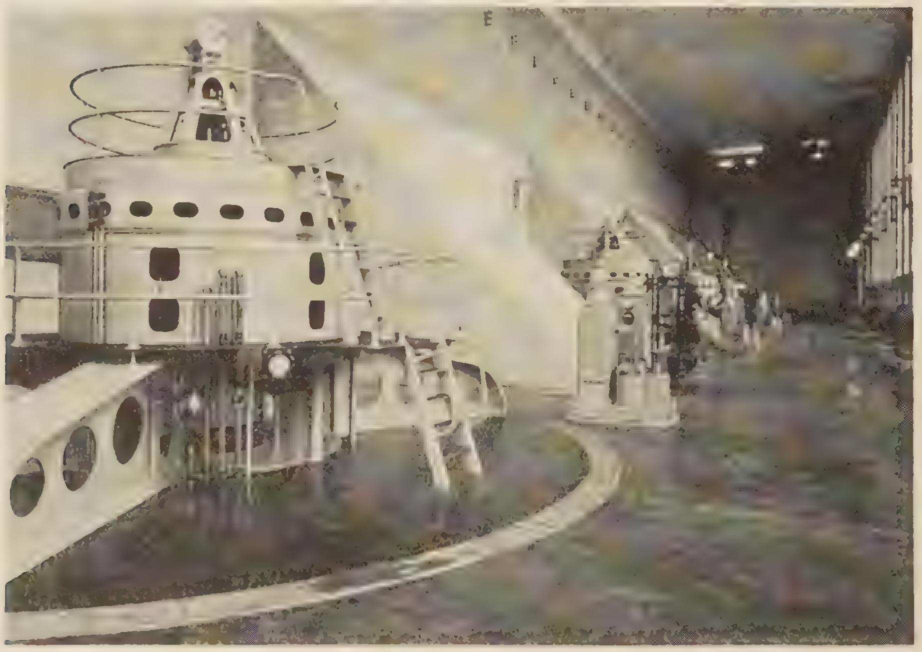
Cellular dams of reinforced concrete and multiple-arch dams have been utilized to some extent but some questionably designed structures, many poorly constructed ones, especially for severe climatic conditions and steadily decreasing costs in the production of mass concrete, have mitigated against any widespread use of cellular dams. A better understanding of the problems involved in the temperature changes in multiple-arch dams may make this type of structure more prevalent in the southern half of our country in the future.

It is almost a universal custom in this country to place gates on spillways for the purpose of increasing the storage available and in order to utilize all of the land which must be purchased to the greatest possible extent.

Intakes and Conduits

The predominance of relatively low-head plants in this country and the tendency to use very large units has necessitated a careful scrutiny of the problem of intake design. Early screening structures were built of a combination of concrete and structural steel

THE CALDERWOOD DEVELOPMENT ON THE TENNESSEE RIVER
(The arch dam is 230 ft high with a low dam below to form a stilling pool 35 ft deep.)



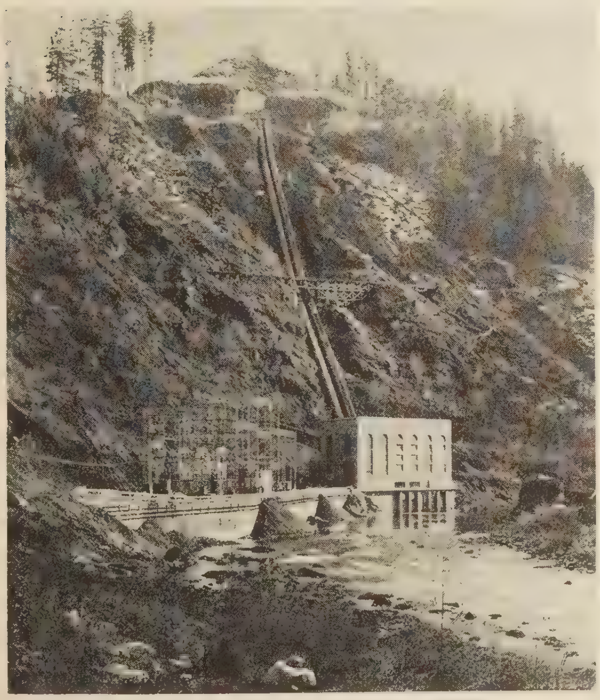
INTERIOR OF THE POWERHOUSE AT THE JORDAN DAM DEVELOPMENT ON THE COOSA RIVER IN ALABAMA
(The plant has four 25,000-kw units operating at 100 rpm The rated head is 90 ft.)

without much attention to the possible deterioration of either type of material. This shortcoming has been corrected in two ways, one, by the use of all reinforced concrete for the fixed structure, and the other by the use of all structural steel. Concrete is more expensive and presumably need never be replaced while structural steel is relatively cheap in first cost and easily replaceable when properly designed with that end in view. A splice in the vertical members at an extremely low water elevation makes it possible to replace the top or fast deteriorating section quite easily, and bronze anchor bolts and nuts make the replacement of the whole structure possible, with the aid of a diver, at some distant year of the future.

Mechanical rakes are successful and utilized where the amount of trash is appreciable. Compressed air has been found effective and is utilized extensively for lifting trash on the screens to the water surface, where it can be removed and disposed of. It is also useful in pumping warm water from the bottom of the reservoir to the surface and in this way is helpful in avoiding ice troubles around screens and at gates on the spillways.

There has been too great a tendency to design intakes on the assumption that increasing the velocity of flow was the symmetrical opposite of decreasing the velocity. Experiments with models have shown that an increase in velocity can be accomplished very quickly and that consequently elaborately long bellmouths and a multiplicity of large gates necessitated by the use of such an entrance, are not necessary and certainly are not justified by reason of any economic advantages to be obtained thereby. For medium-head plants in which the units are placed as close as possible to the downstream toe of a bulkhead wall, the reduction in the length and cross section of the conduit and the confining of the water within a steel penstock limits the uplift effect of the water and provides more weight in the upstream side of the wall.

The Outdoor-Type Morony Development on the Missouri River in Montana Showing the Low Powerhouse and Gantry Crane
(Installed with two 22,500-kw units operating at 81.8 rpm under a rated head of 82.5 ft.)

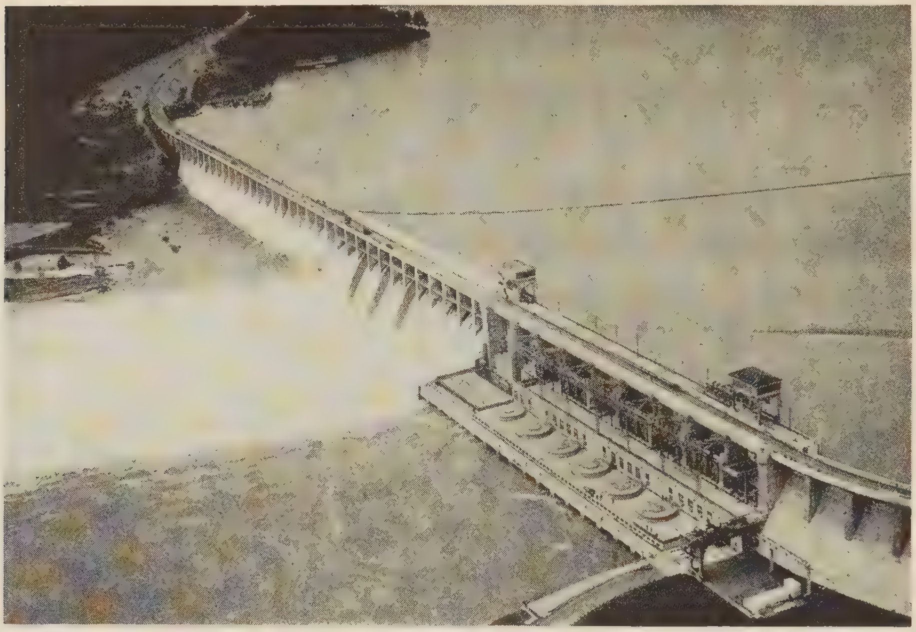


Oak Grove Development on the Clackamas River in Oregon
(Power developed by two 25,000-kw units operating at 514 rpm under a rated head of 849 ft. The highest head reaction units in the United States are located in this station.)

Canals of course continue to be the cheapest method, where favorable topography exists, for conducting water from diversion point to forebay. The use of canals, however, has been very much reduced during recent years because the low cost, permanency, freedom from operating troubles and the additional storage obtained by building a dam with power plant adjacent, have outweighed the use of canals in low- and medium-head developments, and in the case of high-head plants, because of climatic and topographic conditions which generally make the canal still more unreliable and expensive to operate. The use of canals in our hydroelectric plants during the past 15 years has been rather exceptional. They are almost invariably lined with concrete, although irrigation practice has shown that in mild climates a very thin coat of mortar shot from a gun over a wire mesh reinforcement may be more economical.

Wooden flumes have proved to be economical and effective as water conduits in many of our developments heretofore and generally these are being replaced with the same type of structure, although conditions have not been favorable in recent years for very many new projects involving wooden flumes. Canals and open flumes are at a disadvantage for low-load-factor projects unless there is storage capacity between them and the generating station.

Wood-stave pipe lines seem to be a type of structure peculiar to the United States and this type of pipe continues to be utilized where conditions are suitable for pipes up to as large as 12 to 16 ft in diameter. In most parts of the country they still continue to show a very considerable economy over pipes built of plate steel.



Osage Development on the Missouri River

(Installed with six 21,500-kw overhung units operating at 112.5 rpm under a rated head of 90 ft.)

The earlier wood-stave pipe lines were either fully buried in the ground or buried to the horizontal diameter. It was found that in most situations much more rapid decay resulted in the case of buried or partially buried wood-stave pipes. Fine tightly packed soil, which is thoroughly saturated by the leakage from the pipe itself, is favorable to long life. In most locations, however, it has been found that the best results could be obtained by supporting the pipe above ground. A great majority of the larger sized wood-stave pipe lines for hydroelectric plants constructed during the past 15 years have been so constructed. Wooden saddles have been utilized on minor installations but in the more important projects, reinforced-concrete saddles or structural-steel saddles extending almost around the bottom half of the pipe have been utilized. These saddles are placed accurately on masonry foundations, the pipe being erected in the saddles previously fastened in place.

The slight amount of leakage which is involved in continuous wood-stave pipes tends to saturate reinforced-concrete saddles and places a severe test upon the permanency of such concrete when used in climates having severe winter weather conditions.

In the case of both continuous wood-stave pipe and plate-steel pipe utilized as flow lines on almost a horizontal grade for hydroelectric plants, a considerable amount of engineering analysis and model testing has proved to be justified in order to determine the most economical design and spacing of saddles, and the stiffening necessary on the pipe. The design of saddles and stiffeners is governed by the problem of filling the pipes rather than by the load carried after the pipe is filled and under pressure.

In the use of plate-steel penstocks, riveted connections have until recent years been used in the great majority of projects. For extremely high heads, butt-welded joints have been used on the longitudinal seams with either riveted or bolted flange connections for the circumferential seams. In recent years the development of electric welding both in the shop and in the field indicates that this type of welding will be used more prevalently in the future.

Pressure tunnels have not been used extensively in this country although we have one project in which this type of conduit was used for a length of 33,000 ft and a maximum head of over 800 ft. Exceptionally favorable geologic conditions were present and the conduit has proved to be a complete success, although it was lined with only a minimum amount of unreinforced concrete. It is possible where the formation is favorable that this type of conduit will be used more in the future, particularly in view of the development of machinery for lining tunnels with concrete and greater familiarity in the use of grouting machines for tightening the structure adjacent to the conduit after the lining has been placed.

In subdividing flow lines or in taking off branch lines for different units in a power plant, it is the general practice to use wyes in these flow lines so as to present no abrupt changes in direction of flow or velocity. This is somewhat in contrast with the European custom of extending a penstock parallel to one side of the generating station and taking off a branch to each turbine by means of a tee connection.

The differential surge tank has been used in this country for over 20 years and while its adoption by engineers in this country was rather slow, it is now universally accepted as being the most economical method of taking care of the surges in long flow lines.

Penstock Valves

Gate valves designed in accordance with standard waterworks practice have proved satisfactory for moderate heads and small sizes, but as larger sizes have been required, standard valves have not proved to be adequate although satisfactory results have been obtained where the so-called follower-ring type of gate valve has been utilized. The cheapest, reliable large valve, and one which has been extensively utilized, is the pivot or butterfly valve. There has been an extensive and successful use also of the hydraulically operated needle valve. The Escher Wyss rotary-type valve has been used in this country to only a very small extent.

In the simplification of some of our plants, ecespially those where only one unit is supplied from one penstock, it has been

found practicable to omit any valve at the lower end of the penstock for heads as high as 200 ft. This simplification has proved to be quite satisfactory but necessitates the installation of a very reliable intake gate.

Switches and Transformers

In generating-station design, the practice of housing high-voltage transformers and switches has been almost entirely abandoned. It is generally the custom to design the substructure just large enough to contain the water turbine in a substantial block of masonry with a platform overhanging the tailrace providing space for the high-tension step-up transformers. In recent years even busses at generator voltage have been eliminated or have been placed out of doors so that the superstructures have been limited in size to the size of the masonry comprising the substructure. It has been found that with the auxiliary equipment simplified, practically all of it could be placed in the space around the unit made available by reason of the nature of the design of the turbine and generator.

TABLE 2 HYDROELECTRIC PLANTS WITH OUTDOOR CRANES

Development	Operating company	State	Number of units	Capacity of each unit, kw	Year of initial operation
Jackson Shoals	Alabama Power Co.	Ala.	2	500	1912
Drop	Pacific Pr & Lt Co.	Wash.	1	1,400	1914
Olmsted	Utah Pr & Lt Co.	Utah	1	5,500	1917
Cove	Utah Pr & Lt Co.	Idaho	1	7,500	1917
Thousand Springs	Idaho Power Co.	Idaho	1	6,000	1920
Mitchell Dam	Alabama Power Co.	Ala.	3	17,500	1923
Powerdale	Pacific Pr & Lt Co.	Oreg.	1	6,000	1923
American Falls	Idaho Power Co.	Idaho	4	6,000	1924
Blanchard	Minnesota Pr & Lt Co.	Minn.	2	6,000	1924
Otsego	Consumers Power Co.	Mich.	2	850	1925
Lewiston	The Washington Water Pr Co.	Idaho	2	5,000	1927
Norwood (Tillery)	Carolina Pr & Lt Co.	N. C.	2	22,000	1928
			1	18,000	1928
Merced Falls	San Joaquin Lt & Pr Co.	Calif.	1	3,440	1930
Morony	The Montana Power Co.	Mont.	2	22,500	1930
Ariel	Inland Pr & Lt Co.	Wash.	1	45,000	1931
Carpenter	Arkansas Pr & Lt Co.	Ark.	2	28,000	1931
Dam No. 7	Kentucky Hydroelectric Co.	Ky.	3	700	1929
Osage	Union El. Lt & Pr Co.	Mo.	6	21,500	1931
Twin Falls	Idaho Power Co.	Idaho	1	8,450	1935
Wheeler Dam	Tenn. Valley Authority	Ala.	2	32,000	1937

Outdoor-Type Generating Plants

Excepting for the Hengstey II power plant in Germany and the Vargon development in Sweden, no other instance is known of European engineers adopting the plan of utilizing an outdoor crane, and thereby reducing the superstructure to that size necessary to enclose the generating units only. This arrangement was first used in this country in 1912 and has now been adopted in the case of some of our largest power plants. This scheme is no longer experimental. It has been adopted for 20 generating stations, some of them in locations where our most severe winter climate prevails and the record shows approximately 220 plant years of successful operation.

The outdoor crane has been used in this country at two thermal-electric plants and at a number of substations containing large synchronous condensers. A list of plants using outdoor cranes is given in Table 2.

It is claimed that both the cost of and time for the construction of a generating station can be saved by the use of outdoor cranes. It is believed, however, that conservatism has prevented their more general adoption in this country. It is in stations having a large number of units that the larger percentage of savings in cost can be shown for the outdoor-crane type of design.

While a number of the early hydroelectric units, especially in the larger sizes, utilized vertical shaft multirunners with direct-connected generators, horizontal-shaft units were the predominant type between 1900 and 1910, after which time the single-runner, vertical-shaft type of unit began to gain the ascendancy, a strong impetus being given to the vertical-shaft type at that time by the development of the Kingsbury thrust bearing. Since 1915, the single-runner, vertical-shaft, direct-connected generator type of unit has been almost universal for reaction-type turbines.

The vertical-shaft type of unit with three guide bearings, one on top of the turbine, one below, and one above the generator rotor, with the thrust bearing located above the upper guide bearing and supported by means of brackets on the top of the generator stator frame, with a direct-connected exciter above the thrust bearing (for speeds of 100 rpm and higher) had become practically a standard type in this country by 1920.

Umbrella-Type Generator

In 1923, a decided variation in this arrangement was introduced, which has been called the "umbrella" or "overhung" type of unit. It has been advocated and used only for units in the lower speed range and, depending on the kilowatt capacity of the generator, it is feasible to use this type up to speeds between 200 and 300 rpm.

In the umbrella-type unit, the thrust bearing is placed under the generator rotor and is supported on brackets resting on the top of the cylinder separating the turbine and the generator. The three guide bearings have been reduced to two in most cases, one being located as high up as possible and directly under the thrust bearing, the other being located on the turbine head cover. In some of the higher-speed units a relatively light bracket and guide bearing has been placed on top of the generator as well. This has been deemed desirable in cases where the speed approaches the higher range and a direct-connected exciter is mounted on top of the generator. The change in the location of the thrust bearing from above to below the generator was not new in 1923. That scheme was utilized in several of our more important stations in the early period of hydroelectric development but it had been practically abandoned by 1915.

The advantages of the umbrella type are that it reduces the guide bearings from three to two, materially shortens the span necessary for the bracket supporting the thrust bearing, and makes it possible to dismantle the generator for inspection and repairs without disturbing the thrust bearing, shaft, and turbine.

With impulse-type units, horizontal shafts are almost the universal practice. The number of impulse-type installations in important hydroelectric projects in this country during the past 15 years has been relatively small. The few large installations which have been made consist of two bearing units, the generator being mounted in the center and an impulse turbine overhung on each end of the shaft. One nozzle on each runner is the general practice.

Generator Excitation

There has been a continuing tendency toward simplification in the provisions for exciting the main units except in the very large generating stations containing a large number of units. In some of these larger plants, a-c house units provide power for driving a motor-generator exciter located close to each unit. Spare motor-generator sets are generally provided for use in case of trouble with the regular unit.

In some of the larger plants and in practically all of the smaller and least important plants, except those in which the units operate at extremely low speeds, the direct-connected exciter is the more prevalent type. It has been customary to provide some type of reserve exciter such as a motor-driven or a water-wheel-driven exciter which can be connected for use on any one of several of the main units, but on account of the fact that present-day exciter generators are among the most reliable pieces of ma-

chinery used in connection with hydroelectric-power generation, there is a tendency toward the elimination of spares and making the use of each unit entirely dependent on the availability of its particular direct-connected exciter.

In many of the slower-speed units, on account of increased cost of slow-speed exciters, motor-driven exciters are used and dependence for the starting of the station and a power supply, if the plant happens to be completely shut down, is placed on the transmission line or lines entering the station from the transmission system.

Pilot exciters are coming into use to an increasing degree with the larger machines. The inherent advantages obtained are quick-response excitation which helps to maintain system stability, the ability to reach lower stable values of field excitation for leading power-factor conditions, and the elimination of the generator field rheostat with consequent saving in space and cost.

Ventilation

In the early stages of hydroelectric development, generators were cooled simply by fans built into the machines or so arranged as to circulate air through the coils of the armature. No attempt was made to separate the incoming from the outgoing air and, in hot climates with only the thermocycle to change the air in the generating-station building itself, this often resulted in limiting the capacity of the generators. As the vertical-shaft type of unit became more popular, improvements in ventilation were gradually made by introducing air from outdoors through a duct to the underside of the generator and discharging it into the generating station where it escaped through the windows. Later on this system was improved by conducting the hot air discharged from the generators out of the generating station through a duct and in many cases the air entering the generator was passed through an air washer for the purpose of cleaning and cooling the air and increasing the generator capacity.

About ten years ago, the completely enclosed generator came into use, one in which the air is circulated alternately through the generator and through cold-water cooling coils. This method of cooling generators is utilized in the great majority of installations at the present time. It is particularly adaptable to hydroelectric units where there is generally an ample supply of sufficiently cold water to carry away the heat in a comparatively small space, and this method of cooling provides greater freedom and more space for auxiliaries directly around the unit itself than is the case when air washers and air ducts are utilized.

Generator Voltages

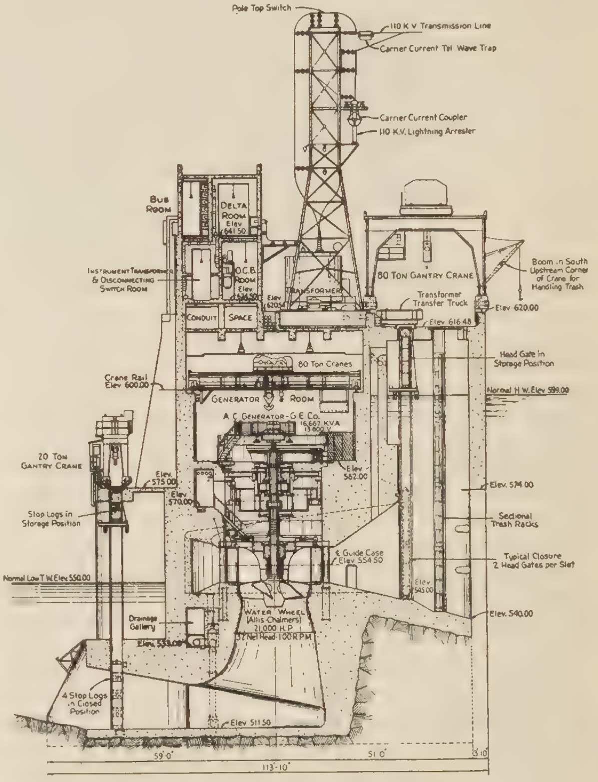
In the early stages of hydroelectric development 2300 v was the common generator voltage. This is seldom used now and 6900 v is standard for the smaller machines and 13,800 v for those of the larger sizes. The use of busses at generator voltage was quite common up to about 1920 but in stations built since that time the tendency has been to get away from this arrangement. This same tendency is apparent in the design of our thermal-electric stations as well. Many installations now provide no oil circuit breakers between the generator and the transformer which is installed as a unit with the generator. In many such cases an auxiliary house-service transformer is tied solidly on to the generator leads.

Transformers

High-voltage step-up transformers are now almost universally placed either directly against or outside the generating-station building and the unit high-voltage circuits connecting with high-voltage switches and busses are located either on the top of the generator station and dam or in a switchyard located at some distance from the generating station where a sufficiently large area of flat ground is available. This is particularly desirable when the generating station is the focus of a number of high-tension transmission lines.

Bearings

Twenty-five years ago the Kingsbury bearing greatly simplified the thrust-bearing problem by eliminating the circulation of oil, particularly at high pressure. In some of the earlier Kingsbury bearings the oil was circulated between the bearings and cooling tanks by means of exterior pumps, but the universal practice at the present time is to enclose the bearing in a bath of oil and in this oil bath to provide coils for keeping the oil cool by circulating cold water through them.



Main Unit

Rock Island Development on the Columbia River in Washington Showing a Section Through the Intake and Powerhouse

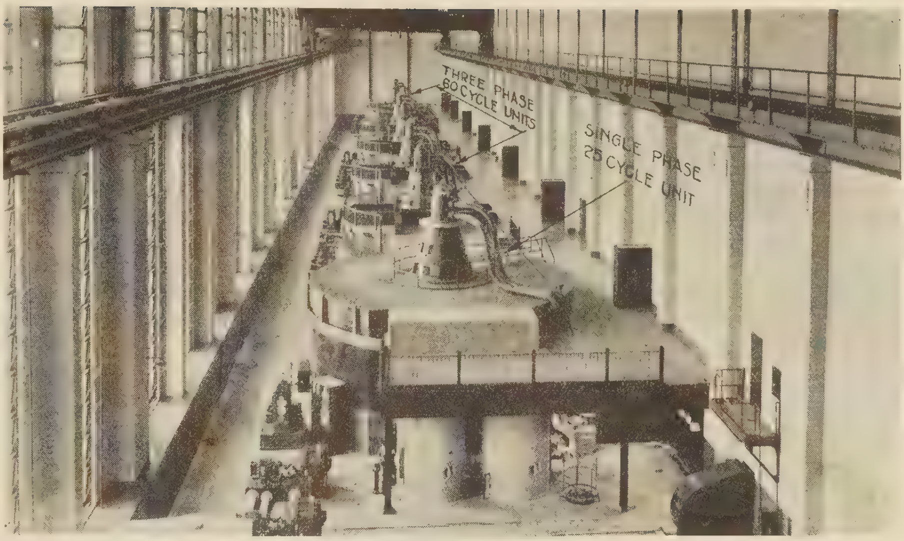
(The installation consists of four 15,000-kw propeller-type units operating at 100 rpm under a rated head of 32 ft. Provision is made for unusually high tailwater.)

Lubrication of vertical guide bearings has been simplified from elaborate central oil-pumping and cooling systems circulating oil to each bearing to one in which a small pump is made a part of the bearing and operated from the main shaft. Careful development of these pumps has improved their reliability and it is quite common to rely on one such self-contained pump for lubricating the turbine bearing and one pump for lubricating the generator bearing or both generator bearings if there are two such bearings on the unit. For the guide bearing directly above the turbine runner, water lubrication has never been abandoned, however, and many units with that type of lubrication are in successful operation.

The development of the umbrella-type unit, having only two guide bearings, of necessity requires very accurate alignment of the lower bearing. The difficulties involved in connection with

the design and operation of the oil-lubricated bearing on the top of the propeller or Kaplan type of runner have revived interest in water-lubricated bearings and the lining of these bearings with rubber instead of lignum vitae is indicated for many future installations.

Turbine and generator shafts are generally made by the respective manufacturer of the machines and are joined by means of a forged flanged coupling. Some operating companies have insisted on the use of one piece of shafting for the whole unit or on sufficient crane clearance and other clearances large enough so that the flanged coupling need never be dismantled after its first erection.



Powerhouse of the Safe Harbor Development on the Susquehanna River in Pennsylvania

(Installed with six 28,000-kw units. The rated head is 55 ft and the speed of 60-cycle units is 109.1 rpm while the speed of the 25-cycle unit is 100 rpm.)

Turbine Types

The Francis type of runner has always been the predominant one in this country because of the relative scarcity of sites suitable for impulse machines. This type of runner has been utilized in quite a number of developments for heads over 600 ft, the highest being an installation under a head of 930 ft. Reaction turbines have been feasible and economical for these higher heads because of the large size of the units involved.

Propeller and the Kaplan movable-vane runners have come into use gradually during the last 15 years, and the installations have gradually increased in capacity and the amount of head involved. In the future, we shall probably see very few installations of Francis turbines for heads under 75 ft since the propeller-type runner is now very generally accepted for low-head installations. One installation of automatically self-adjusting runner blades is in operation but this type of blade control is so new that the opportunity has not yet presented itself for the adoption of many installations of this type.

Scroll cases for the passageways leading to and around the turbine are constructed of materials dependent on the size of the unit and head under which it operates. For extremely low heads, reinforced-concrete scroll cases or open flumes are used. For high heads, cast iron is used for small units and cast-steel, riveted, or welded steel plates are used for the larger units under the higher heads. In many installations the top half of the plate-steel scroll case is not buried tightly into the concrete comprising the substructure of the generating station. Instead the top half of the casing is covered with a crushable material such as celotex, which, by reason of its easy compressibility allows the turbine casing to "breathe" without distorting or overstressing the concrete surrounding the casing.

Draft-tube design has been the subject of much study and laboratory testing. The elbow type of draft tube is the one most widely used, although the vertical tube with variations of a concentric cone of metal and concrete directly under the runner has been used to a considerable extent. The central cone extending all the way up through the draft tube to the bottom of the central part of the runner is now the general practice when this type is used.

In many installations it has been found that the efficiency of the unit is considerably increased at the lower gate openings and that smoother operation and avoidance of water hammer in the draft tube is secured by the admission of air at the top of the runner and draft tube. The amount entering is adjusted automatically by means of levers connected to the gate mechanism and decreases as the gate opening increases, usually becoming zero at about 40 per cent gate opening.

Turbine runners are made of cast iron, cast steel, and various types of bronzes depending on size, capacity, and quality of the water. Construction of runners of stainless steel has been seriously proposed but not as yet put into practice.

Observation of pitting on a great many turbine runners and laboratory tests has shown engineers the importance of cavitation in turbine maintenance. As a result of these studies turbines are now generally set as low as possible relative to tailwater.

Small turbine runners for many years have been made of steel plates pressed accurately into shape and fused to a cast-iron hub and outside ring by casting the iron directly against the plates. This method has been used principally in small installations and has not been very generally adopted in American hydroelectric practice. However, it is being revived now on account of the perfection and reliability of electric welding. The modern method is to cast the hub and outside ring of steel separately and by means of electric welding assemble these cast-steel parts with the pressed-steel plates.

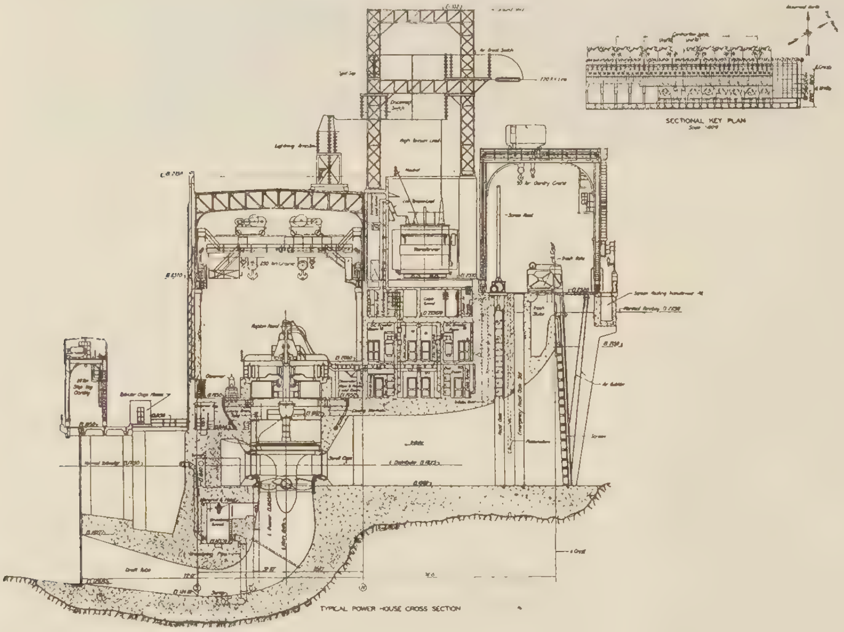
Governors

The hydraulic oil governor actuated by flyballs has been in use almost from the inception of hydroelectric development. It is still used exclusively for governing hydroelectric units, although, of course, it has been improved upon and enlarged in size from year to year. In general, it might be said that most American operators of hydroelectric stations have not insisted upon extreme sensitivity and quick action in hydraulic governors. Many of the power systems have had some steam turbines operating as part of the generating capacity and most of the operators in the past have been content to allow the steam turbines to do the governing, the gate opening of the hydraulic units being set by means of a governor stop or resulting from sluggishness because of purposeful adjustment or neglect. This method of operating has been satisfactory in many of the power systems in the past, but with the extensive interconnections which have come into

use in the past fifteen years, the demand for synchronization and operating interconnections over increasingly large areas of the United States and the demand for better speed regulation, have made it necessary to provide well maintained hydraulic governors on all important units. It is now quite generally appreciated that any governor operated against a stop eliminates just so much governing capacity from the system and changes the governor into practically nothing more than a safety device against runaway.

Automatic Control

Automatic control of the pilot-valve setting is now a definitely accomplished fact both for controlling speed and controlling load. Many of these automatic installations are in use.



Section Through the Powerhouse at Safe Harbor Showing the Kaplan-Type Unit

It has been customary for many years to provide a governor switch on the control board so that the motor used for changing the length of the pilot-valve stem could be actuated by an operator observing either speed or load on the instrument board. The automatic-control apparatus referred to previously does this automatically either for one unit or for a group of units and can be arranged to open and close the gates on a group of units so as to secure the maximum efficiency from the group. This apparatus is applicable to thermal-electric units as well as to hydroelectric units and is utilized on one or more plants of practically all of the areas of the country now tied together and operating in synchronism.

This apparatus does nothing new and does only what can be accomplished by well-trained operators giving continual attention to the speed or load, whichever it is desired to control in any particular station or for any particular unit. It has the advantage, however, that it gives continual attention to the problem of adjusting the governors to secure the speed and load required and sends an impulse to the governor to accomplish this every 2 sec so that accuracy of results has been secured which has never been possible by means of human control. The use of this automatic apparatus makes possible the greater interconnection and synchronous operation of large transmission networks and in many cases makes it possible to transmit power over long lines of small capacity in greater quantities and with much greater reliability and protection against overloading of switches than it has been possible to accomplish heretofore.

Switchboards

The extensive switchboard gallery, one of the important features of the standard plan for hydroelectric stations, referred to previously, is entirely outmoded. It is now called the control room and may be located in almost any part of the building or even outside in a separate building. In some instances, the heritage of the switchboard gallery still compels its location where windows may be provided so that the operators can look into or down onto the generator room. Many designers and operators do not consider it essential that any other part of the plant be visible from the control room but in small stations, it is preferably located for convenient supervision of all operating machinery.

The control room is constructed so as to be as quiet as may be practicable by carefully soundproofing it against the noise created by the main units and auxiliary machinery. It is separately heated, cooled, and ventilated so as to secure more uniform and comfortable atmospheric conditions than is possible in the main part of the station itself.

Increasing attention is being given to the ventilation of all parts of the generating stations, particularly with a view toward securing cleanliness. It has long been the custom to screen all windows and doors but the tendency today is to design generating stations so that all windows and doors can be kept closed all the year round, and the station ventilated mechanically with perhaps a very slightly higher pressure in the building than outside. This feature is especially desirable in semiarid parts of the country where there is a considerable amount of dust in the atmosphere.

Architectural and structural details are generally designed strictly from a utilitarian point of view, factory standards being used in most cases. In many of the larger plants, careful attention has been given to securing a pleasing architectural effect in the superstructure although as a general rule it might be said that American practice places much less emphasis on architectural expression in generating-station buildings than does European practice.

Automatic operation of small hydroelectric plants has presented a fascinating problem to designing engineers for the past 20 years. Several automatic stations are in successful operation, one of them containing a unit of 12,000-kw capacity. Very little progress is being made toward a wider adoption of the automatic plant because of its high cost for extremely small plants and because of the fact that for the larger plants, it has been found that the advantage of not having an attendant is offset by the reluctance of the operators in charge of the property to lock the plant and leave it without a watchman. This has resulted in a compromise in some instances and in so designing the plants that only a very small operating force is required. Where a station is located within a very few miles of another op-

erating station, control cables have been utilized for operating the auxiliary station and controlling it to a limited extent from the control room of the larger station. Many small and unimportant stations are equipped for operation without an attendant under ordinary conditions. An attendant visits the plant once each day and must be present to start and synchronize it if it should automatically shut itself down.

BIBLIOGRAPHY

American Falls: "Umbrella Type Generators," by A. C. Clogher, *Electrical World*, vol. 92, 1928, p. 1289. Also, "Hydroelectric Plant Construction Simplified by Use of Cranes," by A. C. Clogher, *Electrical World*, vol. 93, 1929, p. 345.

Ariel: "Ariel Hydro Development," by A. C. Clogher and W. S. Merrill, *Electrical World*, vol. 99, 1932, p. 442. Also, "Ariel Project Engineered for Economic System Operation," by A. C. Clogher and W. S. Merrill, *Electrical West*, vol. 68, 1932, p. 118.

Balch: "Balch High-Head Power Project Well Under Way," *Engineering News-Record*, vol. 97, 1926, p. 836. Also, "Erecting a High-Head Penstock on the Balch Project," *Engineering News-Record*, vol. 98, 1927, p. 406. Also, "Balch Hydro Plant to Operate at 2740-ft Head," *Power Plant Engineering*, vol. 30, 1926, p. 443.

Blanchard: "Umbrella Type Generators," by A. C. Clogher, *Electrical World*, vol. 92, 1928, p. 1289. Also, Hydroelectric Plant Construction Simplified by Use of Cranes," by A. C. Clogher, *Electrical World*, vol. 93, 1929, p. 345.

Boulder: "Hydraulic Valves and Gates for Boulder Dam," by P. A. Kinzie, *Mechanical Engineering*, vol. 56, 1934, pp. 387, 523, 593, 657, 741. Also, "Boulder Dam Generators," by L. N. McClellan, *Mechanical Engineering*, vol. 56, 1934, p. 409. Also, "Turbines for Boulder Dam," by I. A. Winter, *Mechanical Engineering*, vol. 56, 1934, p. 415. Also, "Penstocks for Boulder Dam," by C. M. Day and Peter Bier, *Mechanical Engineering*, vol. 56, 1934, p. 451. Also, "The Construction of the 115,000-Hp Boulder Dam Turbines," by W. M. White, *Mechanical Engineering*, vol. 57, 1935, p. 539.

Calderwood: "Calderwood High-Arch Dam Designed With Deep Cushion Pool to Receive Overflow," *Engineering News-Record*, vol. 103, 1929, p. 954.

Dam No. 7: "A Hydroelectric Plant on Stilts," *Electrical World*, vol. 91, 1928, p. 494. Also, "Hydroelectric Plant Built on High Piers," by L. F. Harza, *Power*, vol. 67, 1928, p. 1132.

Drop: "Hydroelectric Plant Construction Simplified by Use of Cranes," by A. C. Clogher, *Electrical World*, vol. 93, 1929, p. 345.

Fifteen Mile Falls: "Fifteen Mile Falls Lower Development on the Connecticut River in the Towns of Monroe, N. H., and Barnet, Vt.," by C. R. Bliss, *Journal of the Boston Society of Civil Engineers*, vol. 19, September, 1932, p. 373.

Jackson Shoals: "Hydroelectric Plant Construction Simplified by the Use of Cranes," by A. C. Clogher, *Electrical World*, vol. 93, 1929, p. 345.

Jordan: "Cofferdams and Stream Control at Jordan Dam, Alabama," by Lee Warren, *Engineering News-Record*, vol. 106, 1931, p 804.

Lewiston: Sketch of proposed Lewiston hydroelectric development, *Journal of Electricity*, vol. 56, 1926, p. 504. Also, "Outdoor Generators for Lewiston Hydro Plant," *Electrical World*, vol. 93, 1929, p. 428.

Merced Falls: "Semiautomatic Hydro Plant Utilizes Variable Flow," by H. K. Fox, *Electrical World*, vol. 96, 1930, p. 991. Also, "A Semiautomatic Houseless Powerhouse," by H. K. Fox, *Electric Light and Power*, vol. 8, December, 1930, p. 37.

Mitchell Dam: "Automatic Frequency Control at Mitchell Dam," by J. U. Benziger and J. T. Johnson, Jr., *Electrical World*, vol. 93, 1929, p. 1322.

Morony: "'Automatic Operator' for 60,000-Hp Station," by A. C. Clogher and E. N. Peterson, *Electrical World*, vol. 97, 1931, p. 716.

Oak Grove: "World's Record High-Head Reaction-Type Hydraulic Turbine," by C. P. Dunn, *Power*, vol. 61, 1925, p. 868. Also, "The Oak Grove High-Head Turbine Development of the Portland Electric Power Company," by E. C. Hutchinson, *Mechanical Engineering*, vol. 47, 1925, p. 449.

Olmsted: "Hydroelectric Plant Construction Simplified by Use of Cranes," by A. C. Clogher, *Electrical World*, vol. 93, 1929, p. 345.

Osage: "The Osage Hydroelectric Project," by G. R. Strandberg, *Civil Engineering* (U. S.), vol. 1, 1930–1931, p. 243. Also, "Osage River Development to Cost $30,000,000," *Power Plant Engineering*, vol. 33, 1929, p. 826.

Powerdale: "Hydroelectric Plant Construction Simplified by the Use of Cranes," by A. C. Clogher, *Electrical World*, vol. 93, 1929, p. 345. Also, "Putting the Snows of Mount Hood to Work," by L. A. McArthur, *Journal of Electricity*, vol. 50, 1923, p. 483.

Rock Island: "Rock Island Development—Columbia River," by W. D. Shannon, *Civil Engineering* (U. S.), vol. 1, 1930–1931, p. 1111. Also, "Rock Island—A Major Low-Head Hydroelectric Development for the Northwest," by C. C. Dodge, *Electrical West*, vol. 67, 1931, p. 292.

Safe Harbor: "Important Design Elements of the Safe Harbor Hydro Plant," by P. E. Gisiger, *Engineering News-Record*, vol. 112, 1934, p. 33. Also, "An Experience Story of Safe Harbor," by F. H. Annett, *Power*, vol. 78, 1934, p. 380 and p. 438.

Thousand Springs: "Hydroelectric Plant Construction Simplified by Use of Cranes," by A. C. Clogher, *Electrical World*, vol. 93, 1929, p. 345.

Norwood (Tillery): "'Automatic Operator' a Success," by F. M. Nash, *Electrical World*, vol. 96, 1930, p. 342. Also, "Norwood 62,000-Kw Hydroelectric Development," *Power Plant Engineering*, vol. 33, 1929, p. 934.

Twin Falls: "Fool-Proof Hydro Plant," *Electrical World*, vol. 106, April 25, 1936, p. 42. Also, "Twin Falls Hydroelectric Development," by H. L. Senger, *Electrical West*, vol. 76, April, 1936, p. 18.

Waterville: "Waterville Hydro Makes Possible Notable Interconnection," by A. C. Clogher, *Electrical World*, vol. 96, 1930, p. 384.

Wheeler Dam: "Design and Construction of Wheeler Dam," by W. M. Hall, *Civil Engineering* (U. S.), vol. 5, 1935, p. 203. Also, "45,000-Hp Turbine for Wheeler Dam," by F. H. Rogers and R. E. B. Sharp, *Mechanical Engineering*, vol. 57, 1935, p. 499.

Hydroelectric Practice in Canada

By T. H. Hogg,[1] Toronto, Ont.

The author discusses the advances in hydroelectric practice that have been made during the last twelve years, sketching first the revolutionary changes which had taken place in the earlier years of the century. An account of the rapid growth in hydraulic development in Canada, which reached a total of 7,909,000 horsepower by the end of 1935, is amplified by tabular and graphic records of the energy generated in central electric stations in the country.

A survey is then made of the principal changes made in various elements of hydroelectric developments. There has been a great advance in the use of propeller-type units, and their field has been extended in capacity and to higher heads than was the case in 1924, but no radical advance can be recorded in connection with Francis turbines of moderate specific speed. Reference is made to improvements in welding practice in connection with the renewal of pitted parts of turbine runners and in electric drives for governor flyball heads.

A survey is then made of electrical equipment, in which it is seen that, while advances in generator, transformer, connections, and switching practice are comparable to those experienced in the purely hydraulic portions of the installation, the most striking advances have been made in control and automatic-relay protection.

THE WRITER of a paper presented at the World Power Conference at London in 1924, dealing with water-power development in Canada, made this assertion: "It may be stated, with a fair degree of assurance, that the future holds no prospect of revolutionary advances in the art such as have taken place in the last twenty years." That period had seen a gradual increase in unit capacity of turbines, and improvement in their efficiency, an extension in realization of high efficiency over a greater percentage of the full capacity of the unit, perfection of the means of supporting revolving weights, and development of effective means of controlling long water columns.

[1] Chief Hydraulic Engineer of the Hydro-Electric Power Commission of Ontario. Dr. Hogg was graduated from the University of Toronto in 1908 with the degree of B.A.Sc. In 1914 he received the degree of C.E. and in 1927 the honorary degree of doctor of engineering. Before attending the University—from 1902 to 1904—he was on the engineering staff of the Ontario Power Company. His vacations during his University course were spent with the Niagara, Lockport, and Ontario Power Company on high-tension transmission-line construction. After graduation, he remained at the University for a short time, and in 1909 returned to the Ontario Power Company as assistant designing engineer, and was engaged also on the preliminary surveys and as superintendent of construction of the Salmon River plant at Pulaski, N. Y. Dr. Hogg was editor of *The Canadian Engineer* in 1911 and 1912. He became assistant hydraulic engineer of the Hydro-Electric Power Commission in 1913, and chief hydraulic engineer in 1924. He has had charge of the hydraulic design and construction of a score of the water-power projects of the organization, having a total capacity of over 750,000 horsepower.

Contributed by the Hydraulic Division and presented at a meeting of The American Society of Mechanical Engineers, held at Niagara Falls, N. Y., September 17 to 19, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until April 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Reference was made to the position at that time of the propeller-type runner, undoubtedly a revolutionary advance in water-power development, which was, in 1924, just beginning to find its place. European and American practice had diverged somewhat in the development and application of this type of equipment, which is referred to later.

A field inviting investigation at that time was the cause and nature of pitting of turbine runners. The extent to which this proceeded in comparatively brief periods in many installations and the perfect freedom from it in others presented problems of great scientific and economic interest. Decided advances have been made toward a solution of the problems presented by the phenomenon of pitting.

Reviewing changes that have taken place since 1924, we find improvements have been made in governing equipment, in draft-tube design and in simplification of the layout of the hydraulic plant, but, in general, it may be said that the prediction of the improbability of revolutionary advances in the art, in so far as hydraulic plant is concerned, has been confirmed.

This is not true, however, in the broader field of hydroelectric practice. In generation, transformation, and transmission of electric power, notable changes have taken place. It is significant, however, that these changes do not apply so strikingly to generating and transforming equipment as to switching, control, and protective equipment. True, there have been advance in generator design and changes in practice regarding transformer equipment, but these are comparable to the advances made in the turbine, draft tube, and plant layout.

Statistical

In common with many other countries, Canada has experienced a rapid growth in water-power development. Developed water power, which at the beginning of the century totaled less than a quarter of a million hp, through a fairly rapid growth reached a total of 3,590,000 hp by 1924. The rate of growth thereafter for eight years was at the extremely rapid rate of 440,000 hp per year, so that the total developed power exceeded 6,125,000 hp at the end of 1930. It was hardly to be expected that the rapid growth which took place under the impetus of the business expansion subsequent to 1924 would continue, but, in spite of the adverse economic conditions of recent years, there has been a great increase in developed power, until at the end of 1935 it amounted to 7,909,000 hp.

It is quite true that a portion of the increase since 1930 is accounted for by the completion of developments planned in the years preceding 1930. In view of this, a more significant gage of the growth of the industry is provided by the number of kilowatts generated by central electric stations. It must be kept in mind that central electric stations include only those electric stations which generate power for distribution, and therefore do not include hydraulic and hydroelectric stations generating power for specific industrial establishments. As ninety-eight per cent of the output of central electric stations in Canada is generated in hydroelectric plants, and as the great majority of hydraulic plants are included in central stations, the energy generated in central stations year by year is a very reasonable gage of the growth in importance of the hydroelectric industry. The output of central electric stations in Canada amounted to 9,315,277,000 kwhr in 1924, and to 18,093,802,000 in 1929, after which a decline took place until 1932, when the output amounted to 16,052,057,000; but a subsequent steady increase carried

it to 23,410,000,000 kwhr in 1935. Developed hydraulic horsepower and output of central electric stations year by year since 1924 are shown in Fig. 1.

Power Supply for Mining Industries

An outstanding problem in hydroelectric-power generation is the growth in amount of and special provisions for meeting requirements of mining and related industries. To appreciate the

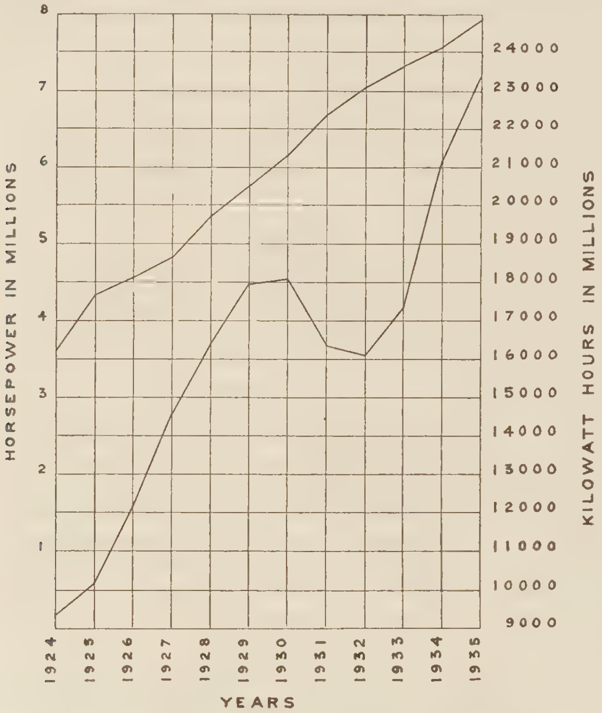


Fig. 1 Installed Hydraulic Horsepower and Energy Generated in Central Electric Stations, 1924–1935

significance of this, it is necessary to consider recent developments in mining in the Dominion.

The remarkable growth of the industry is shown by a consideration of the value of mineral production, which fifty years ago had a value of only $10,200,000, but has grown in recent years as indicated by the following tabulation: 1896, $22,474,256; 1906, $79,286,697; 1916, $177,201,534; 1926, $240,437,123; 1935, $310,162,455.

The value of production was as high in 1929 as in 1935, after which there was a slight decline, from which the industry has now recovered. In considering these figures it must be kept in mind that, while gold has risen in price, nickel has remained stationary, and all other products, metallic and nonmetallic, bring lower prices than the record prices of 1929. Copper, lead, and zinc are now selling at very low prices, lead and zinc remaining close to their minimum value. The present high production thus indicates a greatly increased gross tonnage from the mines, a greater use of power, and wider employment of machinery.

To meet the power requirements of the industry, numerous isolated developments have been necessitated by mines located far from existing sources of power supply and at points to which transportation of equipment is difficult and costly. This latter feature is not new in the mining industry, but in Ontario and Quebec, lacking as they do coal deposits, it precludes the use of fuel-produced power for mining and milling operations. Diesel power is utilized in some places in these provinces, and for preliminary operations in a new field local fuel is used, but one of the chief concerns of the mine manager now is to locate a dependable source of electric power. Probably ninety per cent of the mines in Ontario and Quebec use electric power for all purposes. Furthermore, electric equipment is used more extensively for domestic purposes in the communities in the mining districts than in other parts of these provinces.

Hydraulic Turbines

The assertion in 1924, referred to at the beginning of the paper, that we had at that time probably reached the ultimate in efficiency of Francis-type turbine runners, has been confirmed. No claims have been made for greater efficiency than was obtained at that time in a number of notable developments in Canada and elsewhere. In March, 1925, extensive and careful tests were made on unit No. 7 at the Queenston development at Niagara Falls. This unit has a rated capacity of 58,000 horsepower under a head of 294 ft, and a specific speed of 38. The turbine efficiency realized is believed to be as high as, or higher than, has been obtained in any other installation, and, what is more important from an operating standpoint, unusually high efficiency was realized over a very great range of output. The maximum turbine efficiency was 93.8 per cent, and the efficiency was greater than 90 per cent for 48 per cent of the range in capacity of the turbine.

The Abitibi Canyon development is fairly comparable with the Queenston development and, in so far as the layout and size of the units are concerned, is quite similar to it. The turbines are rated at 66,000 hp under a head of 237 ft, and have a specific speed of 41.5. Tests were made on four of the units at this development in January, 1936, by the same method as was used at Queenston. The maximum turbine efficiency realized was 93.6 per cent, nearly the same as at Queenston, and the range of high efficiency was also practically the same.

Thus, over a period of eleven years no improvement is observed in the efficiency results for large Francis-type runners of moderate specific speed, mainly because the utimate had been so closely approximated at the beginning of that period. Today's turbine, however, is in many respects a better machine, due to improvements in mechanical design and manufacturing methods. One illustration of this may be cited. In two installations of large size in which turbine gate leakage was measured, this amounted to less than 0.3 per cent of full gate discharge in the one case, and less than 0.1 per cent in the other case. Formerly, a turbine gate leakage of one per cent was not considered excessive.

Turbine practice has advanced, however, in the use of high-specific-speed runners, particularly in the extension of the application of these to higher powers and to higher heads than was the case ten years ago. Reference has been made from time to time in technical publications to the difference in European and American practice in the use of the high-speed runner. In Europe, few installations use the fixed-blade propeller-type runner, the field being practically monopolized by the Kaplan runner. In the United States, while the fixed-blade runner is used more frequently, there are also many Kaplan runners in service, some of very large size. But in Canada the field is almost entirely taken up by the fixed-blade runner. A few Kaplan runners are used, but these are of small size.

If one is to search for the reason for this preference for the fixed-blade runner in Canada, in spite of its inferiority to the Kaplan runner in maintenance of high efficiency over a great range of capacity, he will find several explanations. The fixed-blade runner presumably is more rugged than the Kaplan runner, as the latter has numerous parts moving relatively to each other. Moreover, the fixed-blade runner usually has as high maximum

efficiency as the Kaplan runner and in some instances higher. If, then, the lower efficiency of the fixed-blade runner at part loads is not a detriment, its mechanical advantages and high maximum efficiency may prompt its choice. As most of the installations in Canada form parts of large systems, it is often quite feasible to operate individual units always at high efficiency, the plant load being varied, as a unit is taken from or put on the line, by such amounts that all units operating do so at high efficiency. The operation of the Chats Falls plant on the Ottawa River illustrates what may be done in this regard. This plant, operating in the Niagara System of the Hydro-Electric Power Commission, is equipped with fixed-blade runners rated at 28,000 hp under a head of 53 ft at 125 rpm. A study of actual operating results at this plant over several periods, each one week in length, showed an overall plant efficiency as high as 83 per cent. Manifestly, the turbines were operated at all times close to the point of maximum turbine efficiency to obtain so high a result as this for the whole plant.

In other instances in which high-speed runners have been used, the governing condition has not been that of high efficiency, but rather of reliability. The single unit in the Ear Falls plant on the English River in Ontario supplies mining load, and has been called upon for continuous service since it went into operation in December, 1929. In the intervening six years, the unit has been shut down only four times, for a few hours each time, for inspection and cleaning.

Welding of Turbine Runners

Considerable progress has been made in the last ten years in the art of welding, in connection with the restoration of pitted parts of turbines. The corrosion and erosion of runner blades, throat rings, seal rings, and draft-tube sections have been experienced on high-powered as well as on high-speed turbines, and this has, in many cases, proceeded to such an extent that replacement at considerable expense has been necessary. However, through careful investigation along scientific lines by experts, welding processes now make it possible to save affected parts and restore them to efficient operating condition. Thus, for low maintenance expenditure, costly machines can be restored, instead of being replaced, and kept in service with little outage.

Cast steel and forged steel can be welded with little difficulty and, when rust-resisting materials have been applied, on turbine parts where pitting due to cavitation is unavoidable, surfaces treated in this manner stand up satisfactorily in service.

Successful maintenance work is now carried out on cast-iron runners and cast-iron throat rings with a welding process which can easily be used while such parts are assembled with the whole machine. Pitted cast-iron parts are now filled with monel metal, where previously a cheaper grade of welding steel was used. Several years of experience have proved that monel metal is a good substitute to build up corroded parts on turbines.

Welding practice in connection with maintenance of hydraulic turbines is still in a state of flux, and new processes having certain advantages or special fields of application are frequently being proposed and used. Among these might be mentioned the metal-spraying process and atomic-hydrogen process. Naturally, the product of any of these new methods, although giving promise of success, must be subjected to a service test before the method may be accepted as worthy of approval.

Governors

Mechanical drives for governor flyballs have been almost entirely superseded by electric drives. The latter, as at first installed, were not free from defects and disadvantages; in fact, various devices were proposed and used to overcome the defects and assure greater reliability.

A separate set of transformers, connected to the generator leads supplying power directly to the governor drive, gives direct connection between the unit and the governing mechanism, even when interruption occurs which separates the unit from the system. This type of drive is advantageous with high-speed flyballs, and finds frequent application at the present time.

A further advance was made by the addition of slip rings on the pilot exciter when available, from which a power supply was drawn for the governor drive. This method, although possessing advantages over those preceding it, was affected by disturbances in the main electrical system which were not related to the speed changes in the unit which the governing system is designed to control.

Apparently a power supply, quite independent of the main system, is desirable. The necessity for this prompted the development of a permanent-magnet generator, directly connected to the main-generator shaft, but independent of the main electrical system. The governor flyballs, being driven by power from this separate generating unit, are affected only by speed changes in the main-generator shaft, and tend to operate the governor mechanism only as the speed of the unit departs from normal. Satisfactory results are being experienced in an installation of this type, replacing the earlier pilot exciter drive at the Alexander development.

Generators

The use of rolled sections, instead of castings, in the fabrication of the frame and rotor of hydroelectric generators has become virtually standard practice. Improvement in welding technique and the development in rolled shapes have resulted in reduced weights, while the umbrella type of unit has tended to reduce powerhouse superstructure volume.

A tendency to reduce the size of the powerhouse superstructure is noted in several plants where the upstream wall is moved in much closer to the units than in the case of, say, the Queenston development. This tendency is seen in the Alexander and Chats Falls developments in Ontario and the Rapide Blanc and La Gabelle plants in Quebec.

Beyond this, improvements in generator designs are noted mainly in details and in the excitation system; improved insulation methods to prevent coil movement in slots under varying operating temperatures; and bracing windings more securely to withstand short-circuit stresses.

The excitation system of large generators has undergone radical changes in the last ten years. The growth of interconnections and the generally longer transmission systems carrying large and important blocks of power have resulted in stability of operation becoming an important problem. One of the first measures adopted to improve stability was the so-called "high-speed" or "rapid-response" excitation system coupled with low values of armature reactance. While other measures are now considered of greater benefit in the relief of the problem, notably the extremely rapid clearance of faults, the generator excitation system quite commonly includes a pilot-exciter and high-speed voltage regulator.

The tendency to increase generator voltages noted in other countries is not so marked in Canada, partly because only a relatively small number of new developments have been undertaken in recent years and partly because hydroelectric development in Canada almost invariably involves more or less long-distance transmission. When a step-up transformation is involved in any case, there is not the urge to increase generator voltages as is the case when generated-voltage distribution is involved.

The grounding of generator neutrals is a live subject in present-day practice. In a number of cases, where distribution at genera-

tor voltage is not present, generators are being operated with ungrounded neutrals. Damage occasioned by ground faults is thereby minimized, with no apparent countervailing disadvantages. Where distribution at generator voltage is present, the protection of the windings against lightning damage is receiving more attention.

Transformers

The principal trends in transformer design may be traced to the knowledge gained in recent years, as a result of extensive research in the field and in the laboratory in the problems of lightning protection, so that equipment as now designed is virtually lightningproof. The shielded transformer and the so-called "surge-proof" unit are products of this development.

As in the case of generators, refinements in design of transformers are being dictated by operating experience. The oil-insulated water-cooled unit continues to be used most frequently in hydroelectric installations, though the self-cooled unit supplemented in some cases by air blast finds favor where temperatures below —40 F are likely to be experienced. The forced-oil-cooling system is practically unknown in Canadian practice.

Single-phase units are by far the most common, though several installations of three-phase units have been made where economical physical dimensions have apparently been the only limit to capacity.

Application of tap-changing devices has become almost universal practice. In the majority of cases these devices operate only with the transformer deenergized, but "on-load" tap-changing equipment has been developed to the point where standard equipment can be offered to meet almost any problem.

Connections and Switching

The present tendency in station connections and switching facilities is definitely toward simplification and the elimination of duplication, as contrasted with the earlier double-bus and other more complicated arrangements.

This trend was no doubt initiated as development of more remote sites made necessary higher transmission voltages, and, consequently, more expensive switching equipment. The generally smaller number of generating units per plant, the lesser need to provide emergency connections for single generating units as systems expand, and the increasing cost of switching equipment as vastly increased circuit-interrupting speeds are demanded by modern interconnections, are all factors tending to maintain this trend.

Allied with this simplification of connections, however, has been an expansion of the automatic relay protection afforded the component parts of the electrical equipment. Generator-differential or split-phase protection, bus-differential, and transformer-differential are among the types of protection applied.

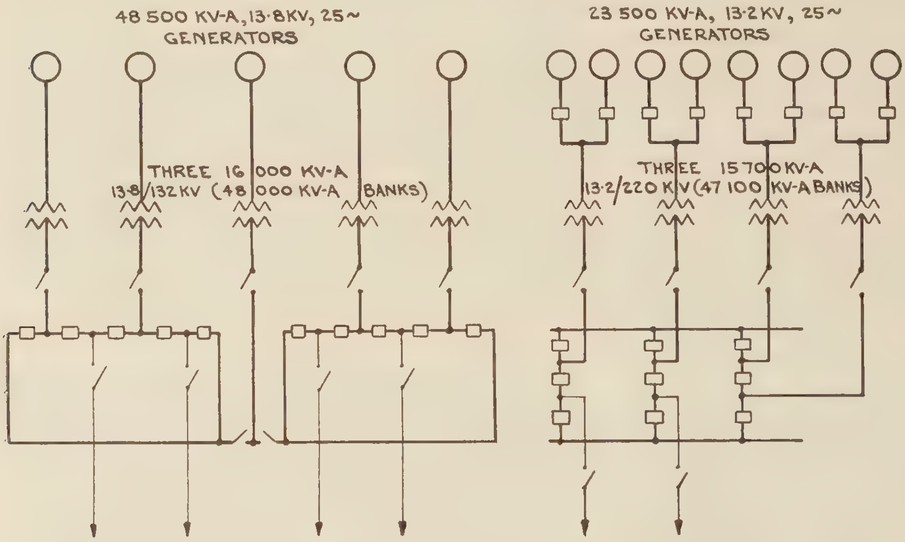


Fig. 2 Main Electrical Connections of the Abitibi Canyon Plant (Left) and the Chats Falls Plant (Right)

In many plants, for example, at Chats Falls, Beauharnois, and Abitibi Canyon, one or more generators and an associated transformer bank of the same total capacity are treated as a unit. Generator breakers, if used at all, are provided only between the unit and the transformer bank, while the high-voltage breaker arrangement may be of the ring or 1.5-type, both of which are shown in Fig. 2.

In the case of the Alexander development, a line diagram of which is shown in Fig. 3, high-tension oil circuit breakers are entirely eliminated. The transformer-bank capacity is arranged to equal that of one transmission line and forms an integral part thereof. This capacity must, however, be greater than that of the generating units connected to it, as, when a transmission line trips out, the station output must pass through the remaining lines and banks. The cost of this excess transformer capacity must of necessity be weighed against the saving in high-voltage switching equipment.

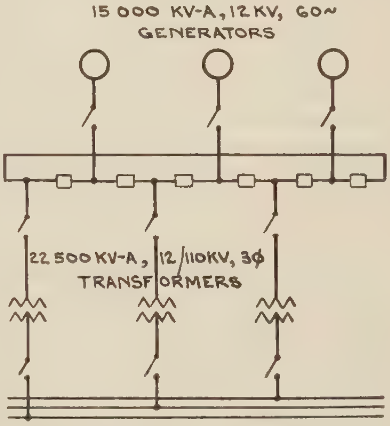


Fig. 3 Main Electrical Connections of the Alexander Development

When generator voltage switching equipment is used, the metal-clad type has found general favor, due to its compactness and its freedom from interference and outage. Such switching equipment is invariably installed within the generating station, as the space requirements are small, though transformers and high-voltage switching equipment have been usually placed outdoors.

FIG. 4 ABITIBI CANYON DEVELOPMENT, ABITIBI RIVER, ONTARIO
(Interior of generating station showing units Nos. 1 to 4.)

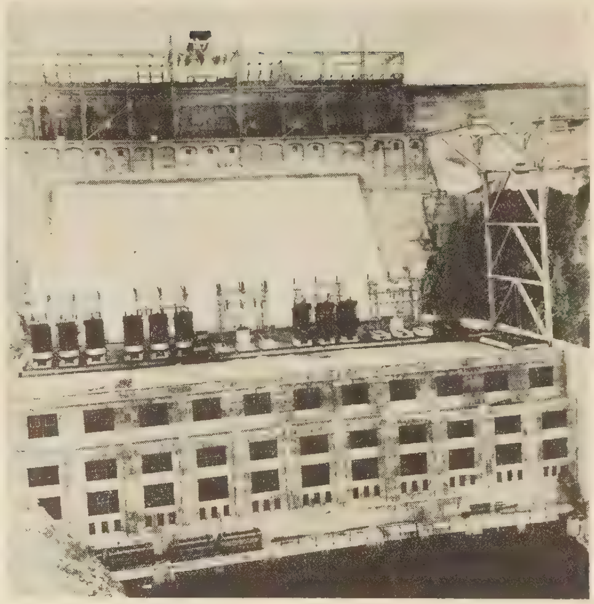


FIG. 5 ABITIBI CANYON DEVELOPMENT
(North face of powerhouse and dam.

The developments in oil circuit breakers in all voltage classes have been toward higher speeds of operation. These developments originate in various means of controlling the behavior of the arc, and much progress has been made in breakers rated at 60,000 volts and over. Standard equipment in these voltage classes is rated to clear the circuit in 8 to 10 cycles on a 60-cycle system, while special high-speed equipment is available operating in 3 to 4 cycles.

Undoubtedly the trend away from massive oil-filled circuit breakers, so noticeable in European practice, is making itself felt in Canada. Up to the present, however, no noteworthy installations of apparatus incorporating radically new principles have been made. The tendency to curtail sharply the use of high-voltage oil circuit breakers has, however, been largely responsible for a considerable improvement in the design and construction of no-load disconnecting and air-break switches. Such switches are quite frequently used to break transformer-bank exciting current and the charging current of up to fifty miles of 132-kv, 25-cycle lines, applications where, previously, oil-filled switches would have been considered almost essential. They are also successfully operating outdoors in temperatures ranging as low as —60 F.

CONTROL AND AUTOMATIC RELAY PROTECTION

The recent developments in miniature-type control switching and switchboard apparatus have brought about a radical change in the size and general design of all electrical control rooms. A compact main control board is provided, upon which are mounted miniature switches and the essential operating instruments. Control is by means of 24- to 48-volt control circuits to subcontrol panels located adjacent to the main apparatus. Graphic instruments, relays, and other equipment are mounted on these subpanels.

This design reduces the space occupied by the essential features of the control system, thus greatly facilitating plant operation and reducing costs. As an example, the control room of the Chats Falls development, designed in 1930 to provide for the ultimate installation of ten units, occupies a space of 18 × 40 ft, the main control board, including operating instruments, being only 12 ft long. By contrast the control room in the earlier Queenston development designed in 1920, also a ten-unit plant, is 70 × 74 ft, the main control boards totaling 51 ft in length.

Control-room lighting has been the subject of extensive investigation in recent years, in fact generally higher levels of illumination are found throughout the more modern plants. Air-conditioned and soundproofed control rooms, virtually isolated from the generator floor, are becoming common practice, some form of control pedestal usually being provided adjacent to the unit, an operator on the generator floor performing the simpler operations of starting and shutting down the unit.

With the continued growth of transmission systems, the tendency toward higher voltage and consequently more heavily loaded lines, interconnections between generating plants and the generally higher grade of service the consumer has been educated to expect, the problems of load control, frequency regulation, and the removal of disturbances by means of automatic relays have become more exacting.

Automatic frequency regulation and the corresponding automatic regulation of tie-line loading is gradually finding a place in Canadian practice, though more extensively applied in other countries.

Extremely rapid clearance of line and station disturbances, while retaining proper selectivity, is the object of modern relay applications. It is expected that practically complete solution of stability problems in high-voltage long-distance 25-cycle transmission will be effected by the combination of these relays with the high-speed breakers previously discussed.

Relays for this service usually operate on the impedance or reactance principle, the mechanical designs having been improved to the point where one-cycle operation has been obtained. The application of pilot-type relaying, where the action of the distant end relays may be controlled by impulses of carrier frequency transmitted over the power circuits, is growing to meet the needs of more complicated system connections. Pilot-type control appears to offer a satisfactory solution to such problems as branched or tapped lines, for which no other high-speed types have been found to be entirely suitable.

In general, the necessary potentials for the operation of these relay types are obtained from two-winding transformers. The potentiometer type of potential source, utilizing capacitance principles, is, however, finding increasing service in a number of ways, for example, in resynchronizing high-voltage lines at main receiving stations following an automatic trip-out.

In summary, the electrical side of hydroelectric development is growing in complexity as the demand for power increases. As the number of generating stations operating in parallel increases, either normally or under stress of emergency conditions, so the associated transmission systems become more complicated. To counteract this tendency, the development itself is being designed to effect the maximum possible simplicity.

Designs incorporate in general the minimum number of units (single-unit plants are not uncommon), the simplest electrical connections, with the control removed from human hands in so far as possible by the application of automatic devices. As these trends of themselves tend to promote economical development of available sites, it is to be expected they will continue.

Conclusion

Interconnection of plants and their separate transmission systems, resulting in the building up of large distribution networks in the more populous parts of the country, had a profound influence upon the design and operation of hydroelectric development ten to twenty years ago. Some of the problems of speed regulation and of pressure regulation in long conduits were partially solved by this tendency, more efficient use of limited water supplies was effected, and development of certain sites made economically advantageous. The design of plants to meet the requirements of industry in remote parts of the country has brought about a return of many of the earlier problems of design. Many of the plants so built are quite isolated from all others and must therefore be designed for continuous and reliable service, frequently under very adverse conditions.

Reference has been made already to one plant in northern Ontario, where continuous service has been given for six years with no opportunity for interruptions for maintenance. Moreover, load variations were such as to make much more severe demands on the governing system than would be the case in plants giving ordinary central-station service.

Extensions of transmission systems into many mining districts are taking place, the same tendency toward interconnection of isolated plants and systems being observed as took place in industrial districts some years ago. Large areas in northern Ontario and Quebec, which are dependent mainly on mining activity, are now covered by an extensive network of transmission lines.

Supercharging of Internal-Combustion Engines With Blowers Driven by Exhaust-Gas Turbines

By ALFRED J. BÜCHI,[1] WINTERTHUR, SWITZERLAND

The author discusses the operation of the Büchi exhaust-gas turboblowers for supercharging internal-combustion engines and scavenging the cylinders, and also explains the principles on which the blowers are designed. He presents indicator, temperature, and entropy diagrams for Diesel engines equipped with the blowers, and gives results of tests conducted on the blowers. A number of internal-combustion engines with exhaust-gas turbo-blowers as used in different types of service are described in the paper. The author also presents a number of curves showing the scavenging effect of the blowers, and the brake mean effective pressure, brake horsepower, and fuel consumption obtained on engines using the Büchi system of turbo-charging.

THE THEORY that supercharging blowers for internal-combustion engines can be driven by turbines utilizing the exhaust gases from the internal-combustion engines themselves is in itself not sufficient to give the advanced results now obtained with this method of supercharging. The advantages which at first appeared to be so obvious were not easy to realize. The exhaust-gas turbo-charging of internal combustion engines had to pass through various phases of development for many years before the theory could be adopted in practice and good results could be obtained.

The oldest patents granted in this field date back to the beginning of the present century. Detailed descriptions concerning its adaptation to all kinds of internal-combustion engines were not available before 1909.[2]

The first tests with exhaust-gas turbines in combination with internal-combustion engines were made in 1911 in the Sulzer Works at Winterthur, Switzerland. The experimental plant worked according to the proposals then made by the author. It is worth noting that during these tests supercharging was effected with low pressures and also with pressures up to about 30 lb per sq in. Combustion pressures exceeded 1400 lb per sq in. with over 200 lb per sq in. brake mep.[3]

Influenced by steam-turbine practice, an endeavor was made at these tests to keep the exhaust-gas pressure ahead of the turbine as constant as possible. Piping from the internal-combustion engine to turbine was designed with a comparatively great volume, i.e., as a receiver. When discussing the latest developments of exhaust-gas turbo-charging, we shall see that its success must be ascribed to a great extent to the abandonment of this constant-pressure theory.

When earlier results are compared with the results obtained today, it can be seen that the exhaust temperatures were then much higher for a given load on the internal-combustion engine and therefore the exhaust valves had to be cooled. At that time it was known that fuel consumption could be improved with exhaust turbodrive, in spite of decreased expansion in the combustion cylinder owing to the exhaust back pressure, since mechanical losses due to friction remain practically constant for cylinders of given dimensions even though mean effective pressures are greatly increased.

In Fig. 1 are given indicator, temperature, and entropy diagrams of the 1911 experimental plant for supercharging pressures of 0, 7.1, 14.2, 21.3, and 28.4 lb per sq in. Line *d-e* of the weak-spring diagram in Fig. 2 shows that the exhaust pressure was practically constant during escape into the turbine.

With the exhaust-gas turbine which was used, no difficulties arose in running, and the increased mean effective pressure was taken by the running gear of the engine quite easily without any excessive wear. In order to obtain still further improvements in the results, it was found necessary to introduce the greatest possible weight of charging air into the engine cylinder, in order, for a given swept volume, to obtain a high specific output with low gas temperatures, little transmission of heat, and also high mechanical efficiency.

The present Büchi supercharging system takes full consideration of these requirements. In this system the cylinder is not only charged with precompressed air, but is also scavenged with a great quantity of cool combustion air in spite of placing the exhaust-gas turbine after the internal-combustion engine and the consequent back pressure in the exhaust.

It was not so easy to find a suitable working process. Because of the rather low efficiencies of the exhaust-gas turbine and the centrifugal blower driven by it for a certain supercharging pressure, approximately the same exhaust-gas pressure as the blower pressure is necessary to drive the turbine with the given temperatures of the exhaust gases. Consequently, a pronounced pressure

[1] Consulting Engineer. Mr. Büchi was graduated from the Swiss Federal Institute of Technology, Zurich, Switzerland, in 1903 with an M.E. degree. Prior to these studies he passed a three years' practical training in the shops of Sulzer Brothers, Winterthur, Switzerland. From 1903 to 1906 he served as designer of Diesel engines, gas engines, and steam engines at the S.A. des Ateliers Carel Frères, Ghent, Belgium. He made a study tour in England in 1907. During 1908 he was engaged as consultant with Honegger Company, Wetzikon, Switzerland, builders of mechanical equipment. From 1909 to 1918 he was chief of the research department for Diesel engines in the Sulzer Brothers' plant at Winterthur. He served as chief engineer in charge of marine Diesel engines, Howaldtswerke, Kiel, Germany, from 1918 to 1919 and from 1919 to 1927 as chief engineer in the Diesel Engine Department of Sulzer Bros., Winterthur. In 1927 he began the organization of the Büchi syndicate for the development of his supercharging system. From 1928 to 1934 he was managing director of the Swiss Locomotive and Machine Works, Winterthur. Since then he has served as head of the Büchi Syndicate, Winterthur.

[2] "Über Verbrennungskraftmaschinen," by A. J. Büchi, *Zeitschrift für das gesamte Turbinenwesen*, vol. 6, 1909, pp. 313, 329, and 347.

Contributed by the Oil and Gas Power Division and presented at the Annual Meeting of The American Society of Mechanical Engineers, held in New York, N. Y., November 30 to December 4, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until April 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

[3] "Supercharging in Internal-Combustion Engines," by A. J. Büchi, *The Engineer*, vol. 140, August 14, 1925, p. 171.

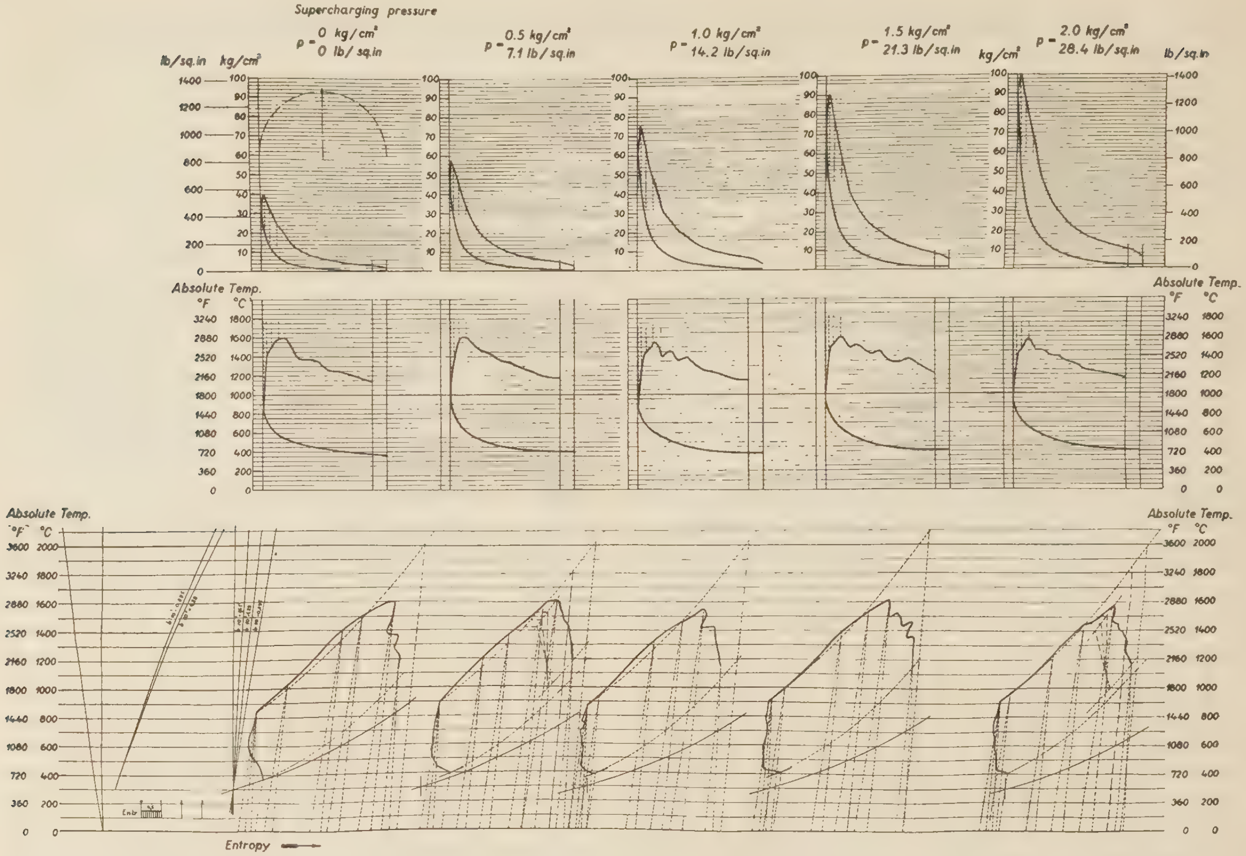


FIG. 1 INDICATOR, TEMPERATURE, AND ENTROPY DIAGRAMS OF THE FIRST DIESEL ENGINE EQUIPPED WITH AN EXHAUST-GAS TURBOBLOWER FOR SUPERCHARGING AND SCAVENGING

difference between charging air and exhaust gases, which is required for an effective scavenging of the working cylinders, is not available. To overcome this pressure condition, the Büchi system makes use of a device which controls to any desired degree the pressure drop required between the supercharging pressure and the exhaust-gas pressure ahead of the turbine. This is effected by means of strong pressure fluctuations artificially caused in the piping between engine and exhaust-gas turbine.[4,5] These fluctuations are created between engine and turbine by choosing suitable cross sections for the exhaust-gas turbine and the volume and cross section of the exhaust piping. Their occurrence at the correct moment and their correct repetition in each working cycle are insured by suitable adjustment of the exhaust valve gear of the engine. Care must also be taken that these forced oscillations are always similar and occur at the proper moment for any given engine load, regardless of different speeds of rotation; also that they are not distorted or even possibly stopped by other effects, such as oscillations in the exhaust pipes. This can be prevented by using proper control gear for the exhaust valves and by choosing suitable dimensions for the exhaust pipes leading to the turbine.

If the working cylinders have to be scavenged, the inlet and outlet means must be open simultaneously during the scavenging period. Also, the scavenging process must not under any consideration be disturbed by the exhaust occurring from another cylinder. If there is disturbance, the gases from the exhausting

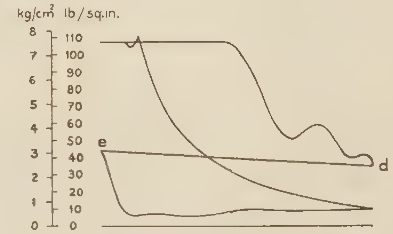


FIG. 2 WEAK-SPRING INDICATOR CARDS TAKEN ON THE FIRST DIESEL ENGINE EQUIPPED WITH AN EXHAUST-GAS TURBOBLOWER

cylinder will find their way through the open exhaust valves into the cylinder that has to be scavenged. This trouble occurs when all cylinders of an engine exhaust into the same exhaust manifold. It is eliminated in the Büchi system by leading the exhaust gases from the engine to one or more turbines through several exhaust pipes, or through exhaust pipes fitted with suitable partitions. In the Büchi system, pipes are arranged so that the exhaust process in one cylinder cannot interfere with the scavenging process in another cylinder. The separation of the exhaust pipes is carried down to the admission nozzles at the turbine, so that it is also impossible for the gases to flow back through the turbine.

The number of cylinders exhausting into one pipe, the time in each cylinder when exhaust begins and stops, and also when admission begins, must be chosen in such a way that no mutually harmful effects may occur. This adjustment must be chosen in various ways to suit the circumstances and in accordance with the number of cylinders.

[4] U. S. Patent No. 1,895,538.

[5] "Pressure Fluctuations in Exhaust Piping," by E. H. Abt, *The Motorship*, London, vol. 12, June, 1931, p. 102.

In Fig. 3 are given the pressure oscillations for various loads in one of the two exhaust pipes of a six-cylinder Diesel engine with exhaust turbo-charging. These were taken by electric indicators and oscillographs. The ignition interval within a group of cylinders amounted to a crank angle of 240 deg. The opening of the exhaust and inlet valves, in terms of crank-angle degrees, is indicated at the bottom of Fig. 3. The period between the initial opening of the inlet valve and the closing of the exhaust valve is designated as the scavenging period. Referring to the pressure variations shown in Fig. 3, it will be seen that at all loads a pronounced depression of the exhaust-gas pressure occurs before the turbine and continues during the whole scavenging period; this is shown by the shaded areas between the approximately constant charging air-pressure curves and the extremely variable exhaust-pressure curves. With 79.5 lb per sq in. brake mep, the exhaust pressure falls to about atmospheric. With higher mean effective pressures it is almost as low, but the pressure peaks of the exhaust pressure and the charging-air pressure are in these cases much higher; this is caused by the

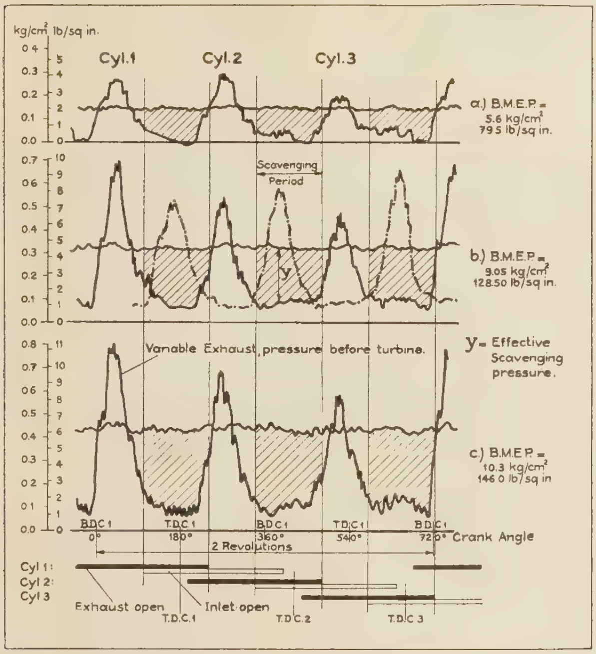


Fig. 3 Pressure Oscillations for Various Loads in Two Exhaust Pipes of a Six-Cylinder Diesel Engine With Exhaust-Gas Turbo-Charging

increase in the quantity of exhaust gas and in its temperature with increasing loads.

The pressure oscillations of the other three cylinders of the same six-cylinder engine, which exhausted into a separate exhaust pipe to the turbine, are to be considered as displaced by 120 deg; this is indicated by dotted lines in the middle diagram of Fig. 3. It can be seen clearly that it would be impossible to scavenge the working cylinders if the exhaust pipes were not separated. Fig. 3 also shows the effectiveness of the method of scavenging discussed here.

How the quantity of scavenging air adjusts itself to the load on the engine can be seen from Fig. 4. Curve a corresponds to an engine in which the load was altered at constant speed, that is, a stationary-type engine. Curve b on the other hand corresponds to a marine engine, in which the load was decreased by reducing the speed in accordance with the propeller law. Curve a was obtained from an SLM Diesel engine with eight cylinders, developing 1000 bhp at 273 rpm with continuous supercharging, while curve b is from an eight-cylinder Harland & Wolff (Kincaid) marine Diesel engine developing continuously 4500 bhp with supercharging. The speed of the latter engine is 112 rpm. The speeds of the corresponding blowers are also plotted in Fig. 4 as curves c and d, respectively.

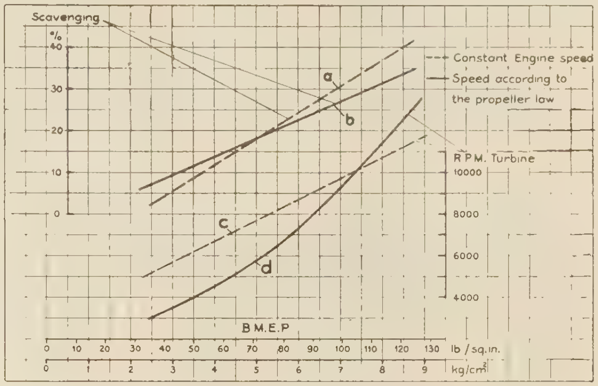


Fig. 4 Scavenging Percentages and Speeds of Exhaust-Driven Turboblowers on Four-Cycle Stationary and Marine Diesel Engines

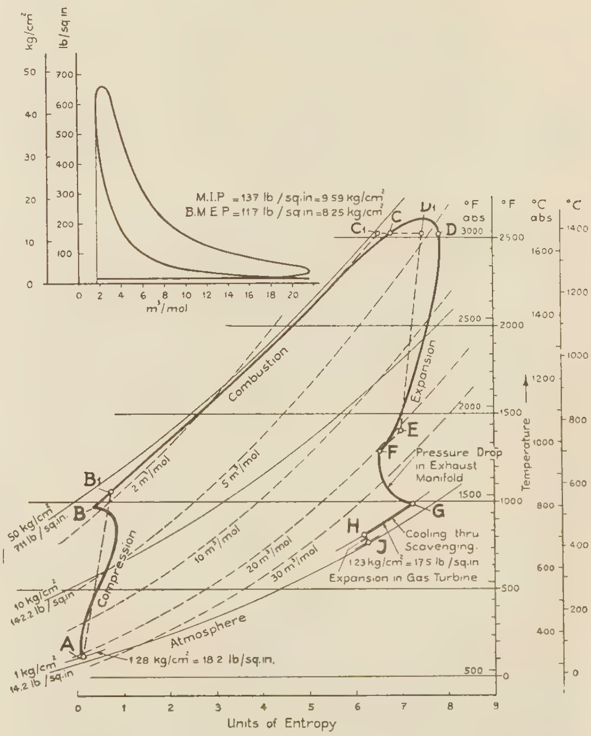


Fig. 5 Entropy and Indicator Diagrams of a Diesel Engine With Exhaust-Gas Turbo-Charging

In Fig. 5 the conditions of pressure, volume, and temperature of the working process with the Büchi exhaust turbo-charging are shown by an entropy diagram. The values plotted were obtained from tests on a Franco Tosi six-cylinder Diesel engine with exhaust turbo-charging. The compression is shown as AB, while BCD represents the combustion, and DF represents

the expansion in the working cylinder. At F the exhaust valves open, and the exhaust gases flow to the turbine, at the same time expanding as indicated by FG. The cooling of the exhaust gases on their way from the cylinders to the exhaust turbine, and particularly their cooling by means of scavenging air passing through the cylinders is shown as GH. Before the exhaust valve begins to open, according to the point F, the gases have a temperature of 967 C abs, or 694 C (1282 F). Due to the pressure drop ahead of the turbine, corresponding to FG, the temperature falls to 532 C (989 F). With 27.4 per cent excess scavenging air, the exhaust gases from the condition at G to their condition at H are cooled to 435 C (815 F). The cooling resulting from scavenging is therefore 97 C (174 F), including a loss of heat of approximately 5 C (9 F). During the expansion of the gas in the turbine, the temperature drops from H to J, or to 407 C (765 F). Therefore, this latter drop amounts to only 28 C (50 F).

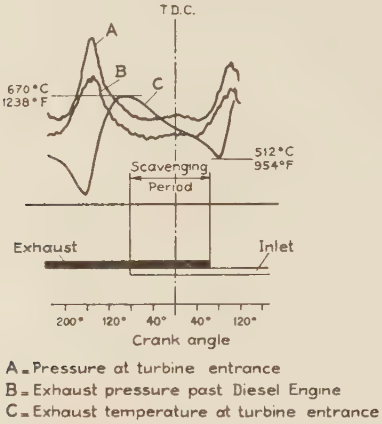


FIG. 6 TEMPERATURE AND PRESSURE VARIATIONS DURING THE EXHAUST AND SCAVENGING PERIOD IN THE EXHAUST MANIFOLD BETWEEN THE ENGINE AND EXHAUST-GAS TURBINE OF A MAN DIESEL ENGINE

The diagram A, B_1, C_1, D_1, E, F, shown in dashed lines, is a theoretical diagram drawn from calculated values having 17.7 per cent heat loss during combustion and expansion, and 4 per cent loss at the beginning of the exhaust; the actual diagram is shown as the solid line A, B, C, D, E, F. Transferring the points of the diagram to pressure-volume coordinates gives the indicator diagram shown in Fig. 5 above the entropy diagram. From this the corresponding indicated pressure can be determined. The mechanical efficiency of the engine in question was measured and found to be 86 per cent. The effective output and the fuel consumption can be calculated from the indicator diagram. Based on the indicator diagram in Fig. 5, the effective output of a six-cylinder engine, of 450 mm (17.7 in.) bore and 700 mm (27.55 in.) stroke, is found to be 1060 bhp[6] at 187 rpm, with 109 lb per sq in. brake mep. The fuel consumption is found to be 160 grams, or 0.353 lb per bhp-hr.

In the entropy diagrams, HJ represents the expansion in the exhaust-gas turbine. Its effective output must be equal to the power required for driving the air charging blower. The symbols used in the calculations are:

G_1 = weight of air delivered for charging and scavenging
R = gas constant for air
T_1 = absolute temperature for the air at blower inlet
p_1 = absolute initial pressure of the air delivered
p_2 = absolute final pressure of the air delivered

[6] In all references to horsepower, metric horsepower is intended.

η_K = isothermal efficiency of the charging and scavenging air compressor
$L_{e(K)}$ = effective work done in compressing the charging and scavenging air, or

$$L_{e(K)} = \frac{1}{\eta_K} \times G_1 \times R \times T_1 \log_e \left(\frac{p_1}{p_2}\right)$$

G_2 = weight of exhaust gases passing through the turbine
c_p = specific heat of the exhaust gases at constant pressure
A = mechanical heat equivalent
t_1' = absolute temperature of exhaust gases ahead of the turbine
t_2' = absolute temperature of exhaust gases after adiabatic expansion in the turbine
G_2 = G_1 + quantity of fuel introduced = kG_1
η_T = adiabatic efficiency of the exhaust-gas turbine
$L_{e(T)}$ = effective output of the exhaust-gas turbine, or

$$L_{e(T)} = \eta_T \times G_2 \times \frac{c_p}{A}(t_1' - t_2') = L_{e(K)}$$

Therefore, the effective temperature drop required in the exhaust-gas turbine is

$$t_2' - t_1' = \frac{1}{k\eta_K\eta_T}\,\frac{RT_1}{c_p \times 428} \log_e \left(\frac{p_1}{p_2}\right)$$

From the foregoing, the action of the supercharging system can be clearly seen. The entire working process takes place at all load factors because the charging air is compressed and on account of the inner cooling of the engine through scavenging air with a low specific volume. In this way, with the same excess air as in ordinary internal-combustion engines without supercharging and scavenging, the indicated pressure becomes much greater. Therefore, for a given output, a smaller cylinder volume is satisfactory. This again results in lower thermal and frictional losses. Increasing the output of the engine per unit of volume therefore implies less thermal losses through cooling and a considerable improvement in the mechanical efficiency, and consequently an improvement in starting conditions. The manifold effects of the scavenging air are of the utmost importance. These effects are:

1 Freeing the compression space from traces of the hot exhaust gases, in contrast to ordinary internal-combustion engines without supercharging. Cooling the cylinder walls and the valves lowers the initial temperature of the working process and thereby increases considerably the weight of combustion air enclosed in the cylinder.

2 Not only the swept space, but also the compression space, is filled with fresh air suitable for combustion. This makes itself apparent in service in perfect combustion and a great capacity for taking overload.

3 The quantity of heat passing away through the cooling water is less, since a part of the heat given up to the cylinder walls is absorbed direct by the cold scavenging air. However, this heat is not lost, but usefully employed in the turbine. This also explains the high thermal efficiency.

4 Mixing the exhaust gases with the cool scavenging air allows the exhaust-gas turbine to run under favorable conditions; complicated cooling devices for the turbine wheels are rendered unnecessary. Consequently, the loss of heat caused by such cooling is absolutely eliminated.

Fig. 6 illustrates the effect of the scavenging. It shows the temperature and pressure course during the exhaust and scavenging period measured in the exhaust manifold ahead of the turbine of a Diesel engine. Curve A represents the exhaust pressure at the turbine entrance and curve B represents the exhaust pressure just past the exhaust valve. This latter pressure is lower on

account of the high velocity and kinetic energy of the gases. Curve *C* represents the temperature changes. The very pronounced drop of the temperature during the scavenging period can clearly be recognized.

A number of internal-combustion engines for different types of service using exhaust-gas turbo-charging are described in the remaining part of the paper, and the results obtained with them are mentioned.

Stationary and Marine Diesel Engines

Fig. 7 shows results obtained in a stationary Diesel-engine plant equipped with two, six-cylinder, MAN, four-cycle engines with exhaust-gas turbo-charging. The exhaust turboblowers are arranged in a compartment next to the engine room, at such a height that the two exhaust pipes from the engines run horizontally to the exhaust-gas turbines. The plant works with a waste-heat recuperator which is fitted after the turbine. In the most favorable case, the fuel consumption is less than 0.36 lb

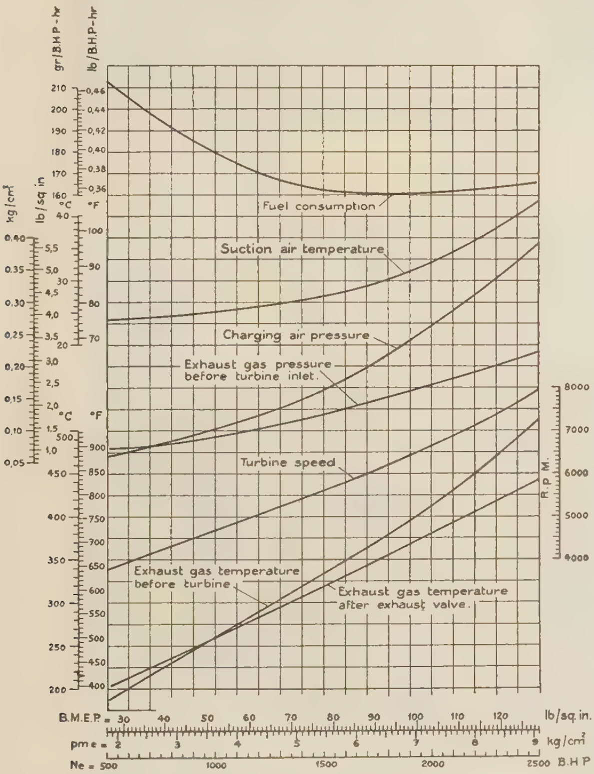


Fig. 7 Test Results of a Six-Cylinder 2250-Bhp MAN Diesel Engine Equipped With Exhaust-Gas Turbo-Charging

per bhp-hr. In spite of the high suction temperature of the air at which the plant is operated (up to 102 F) the exhaust-gas temperatures measured after the valves remain somewhat under 800 F at 120 lb per sq in. brake mep.

In Fig. 8 the results obtained with an SLM Winterthur Diesel engine are plotted. At full load the fuel consumption is 0.36 lb per bhp-hr and the fuel-consumption curve is extremely flat, as with all Diesel engines with exhaust-gas turbo-charging. This means that the consumption at low load is also very small; at 1/4 load it is from 20 to 25 per cent less than that of an ordinary Diesel engine with the same load factor. The excess scavenging air is also plotted in Fig. 8; at full load it increases to over 30 per cent.

An SLM-Winterthur engine with exhaust turbo-charging is shown in Fig. 9. This engine has three cylinders and develops 450 bhp. In this engine, which is installed in the laboratory of the Federal Technical University in Zurich the turbine is mounted in a vertical position directly on top of the engine.

An arrangement of the exhaust-gas turboblower mounted on the forward end of a Humboldt-Deutz eight-cylinder Diesel engine is shown in Fig. 10. The exhaust gases pass downward

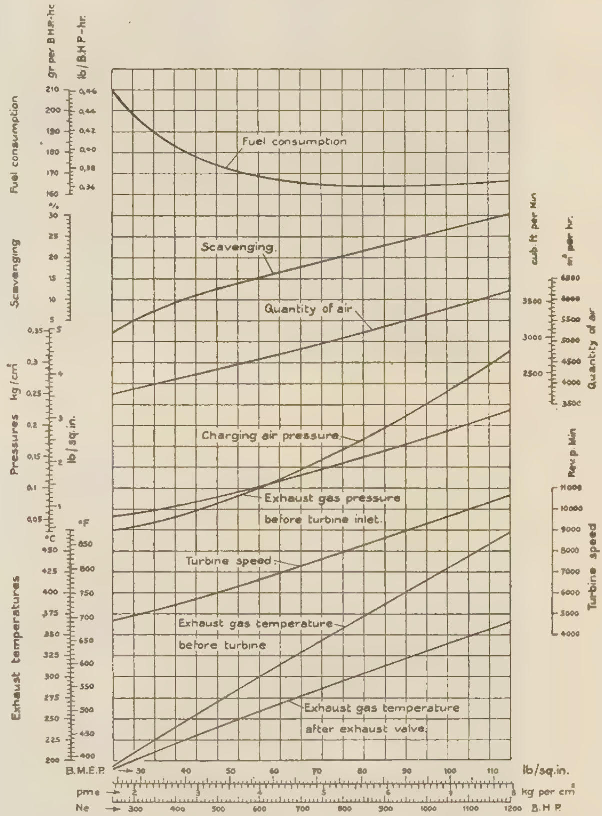


Fig. 8 Test Results of an Eight-Cylinder 1000-1200 Bhp SLM Diesel Engine Equipped With Exhaust-Gas Turbo-Charging

from the turbine through a vertical pipe. Below the turbine and immediately to the right of it, may be seen the flexible expansion joints which have been inserted in order to prevent the turbine from being damaged by the expansion of the exhaust pipes.

In general it can be said that the reduction in the dimensions and weights of the engines which is obtained as a result of the increase in output through exhaust-gas turbo-charging, is of course reflected in price of the engines, and in stationary installations it has also the following advantages: For example, the engine building becomes smaller and the foundations can be of lighter construction. As a result of the reduced cooling required, less cooling water has to be provided, thus leading to further savings, especially when water is scarce, and in cases where it is necessary to erect cooling towers. The reduced fuel consumption also plays an important part, especially when the engine is working with variable loads. In four-cycle engines it is also possible to adopt a rational method of utilizing waste heat in the exhaust gases.

The MS *Reina del Pacifico* of the Pacific Steamship Company

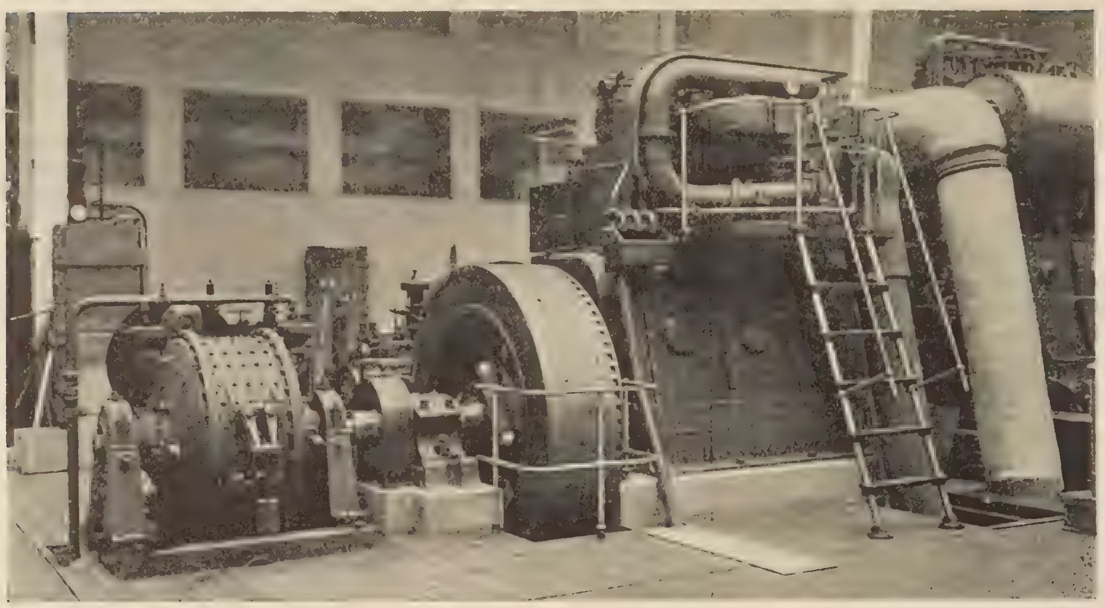


Fig. 9 Three-Cylinder 450-Bhp SLM Diesel Engine With Vertical Exhaust-Gas Turboblower

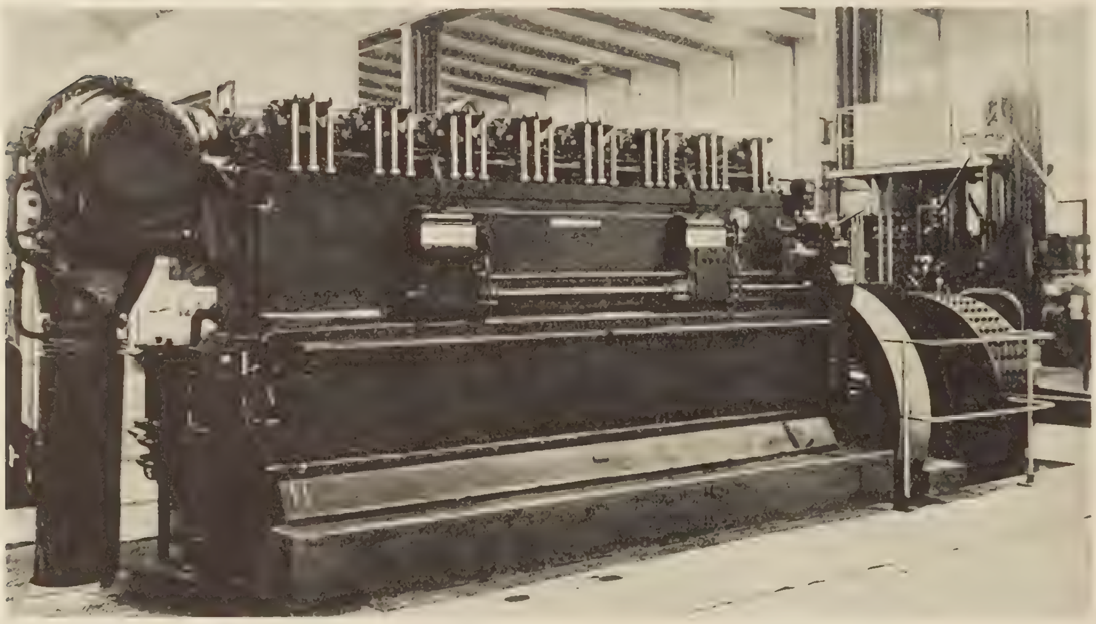


Fig. 10 Eight-Cylinder 750-Bhp Deutz Diesel Engine With Exhaust-Gas Turboblower Mounted Horizontally at the End of the Engine

in service between England and the West Coast of South America via the Panama Canal, is propelled by four, 12-cylinder, Harland & Wolff, single-acting four-stroke trunk-piston engines with exhaust-gas turbo-charging. The trunk-piston design gives an engine very low in height, so that many continuous decks could be arranged far down in the ship. Two cranks in each of the 12-cylinder engines are set the same, and their firing order is also the same. Consequently, in order to avoid trouble in the cylinders during the scavenging period (to which reference has already been made) there are only two exhaust pipes provided for each engine. The exhaust-gas turbines are arranged in an extension of the engine room. After leaving the turbines, the exhaust gases can be led to waste-heat recuperators. Noteworthy in this plant is also the comparatively small size of the auxiliary Diesel-engine plant, a great contrast to Diesel installations with electrically driven charging or scavenging air blowers. As is well known, such installations require large Diesel engines for generating electric energy. With exhaust-gas turbo-charging, the generation of electric energy for the charging air blowers is not required, since the blowers are driven by the exhaust gases from the Diesel engine, without any outside assistance.

Besides for the merchant service, Diesel engines with exhaust

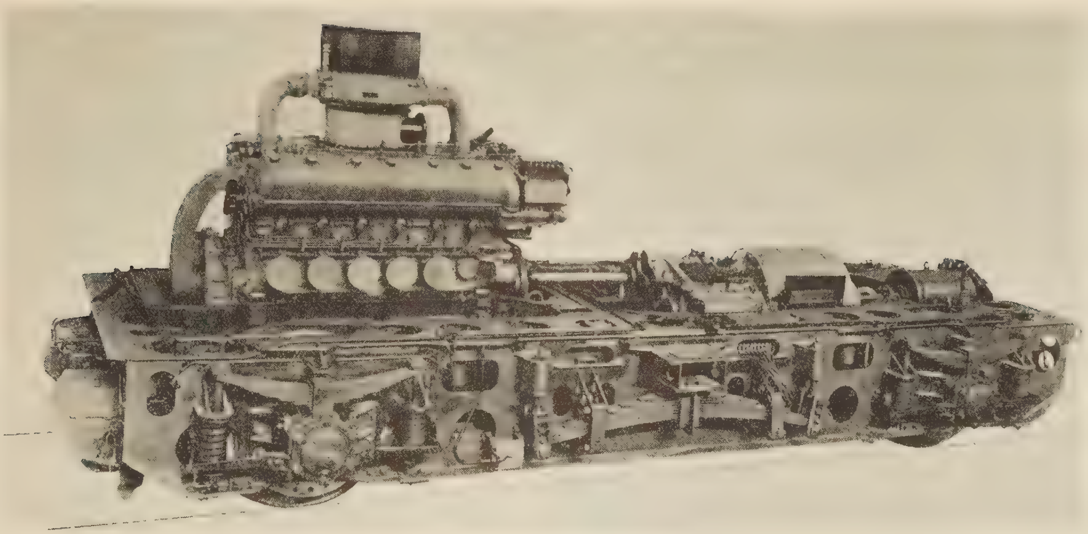


Fig. 11 Rail-Car Truck With a Maybach 12-Cylinder V Diesel Engine. The Engine Has a $6^{5}/_{16}$-In. Bore an 8-In. Stroke, Operates at 1500 Rpm, and Develops 700 Bhp

turbo-charging are particularly interesting for naval vessels. Here, as is well known, small dimensions, low weights and low fuel consumption are of decisive importance, especially at low loads for cruising. On the other hand, the high capacity for overload of the supercharged engines is of great interest for running at full speed.

In ships with Diesel-electric drive, engines with exhaust-gas turbo-charging have already been installed in several cases. One such case is the light cruiser Ilmarinen of the Finnish Navy. Four, high-speed, Krupp Diesel engines, each of 1200 bhp, are installed in this vessel. Because of the high speed of these engines and their being fitted with exhaust-gas turboblowers, it was possible to keep the weight of the machinery comparatively low and to have the engine room small; greater weight could consequently be allowed for the armored plating and the armament.

Each of ten, high-speed, custom-house boats for Mexico were, for reasons of space and weight saving, equipped with two 1350 bhp MAN Diesel engines with exhaust-gas turboblowers.

With regard to the use of exhaust-gas turbo-charging in ships, it may in general be stated that the reduced dimensions and weight of the machinery offer still more pronounced advantages than in stationary plants. The carrying capacity of a vessel is increased, or a vessel may be built of smaller dimensions for the same carrying capacity. The lower fuel consumption increases the radius of action, and marine engines, particularly in the merchant service, have often to run for lengthy periods; a correspondingly greater quantity of cargo can be carried. Because of the smaller dimensions of the cylinders and bearings, the lubricating-oil consumption is also reduced. Engines with smaller cylinder dimensions also require smaller, and consequently cheaper spare parts.

Experience with the many installations now in service has shown, that the reliability of the exhaust-gas turboblowers is excellent.

Traction Diesel Engines

A 1400 bhp Diesel locomotive of the German State Railways is equipped with an eight-cylinder MAN Diesel engine with exhaust-gas turbo-charging. The exhaust-gas turbine and blower are fitted at the flywheel end of the engine, which is located approximately in the middle of the locomotive. No silencer is provided, the exhaust being made direct to atmosphere. The overall length of the locomotive is 47 ft, and the service weight is 75 tons. Its speed is over 60 mph.

Fig. 11 shows a truck of a rail car used on the German State Railways, with a Maybach 12-cylinder V Diesel engine with exhaust-gas turbo-charging. The supercharger is arranged vertically in the middle between the two rows of cylinders. In these engines, of which the German State Railways have a large number in service, a weight of 9 lb per bhp was obtained through the use of exhaust-gas turbo-charging. The engines run at 1500 rpm and can be loaded up to 700 bhp.

Figs. 12, 13, and 14 show the results obtained with a six-cylinder engine of 130 mm (5.12 in.) bore and 170 mm (6.7 in.) stroke operating at a maximum speed 1500 rpm. At 1500 rpm, about the limit of invisible exhaust, 135 lb per sq in. brake mep was reached. As shown in Fig. 14, remarkably low fuel consumption was obtained at speeds varying from 1000 to 1500 rpm.

It can be said that the adoption of exhaust-gas turbo-charging is of pronounced advantage for locomotives and rail cars. An important part is played not only by the reductions made in dimensions, weight, and fuel consumption, but also by the possibility of the adoption of supercharging to get an engine of the required output mounted in such a traction unit.

In traction service, the size of the water and oil-cooling devices is also of importance, first, because of their weight and the space requirements, and second, because of the power required for driving their fans. In this connection the Diesel engine with exhaust-gas turbo-charging proves to be the most advantageous, since in the most unfavorable case it requires coolers and fans about 30 per cent smaller for the same output.

As a result of the small losses through friction in the smaller pistons and bearings, as previously mentioned, the torque required for starting such an engine against no load is also less. Consequently, starting devices of smaller capacity can be used for starting.

Another important point is the fact that, because of the less heat led away, up to 50 per cent more output can be developed with engines without piston cooling. This is of particular significance in engines for traction, but it often plays an important

part in marine and stationary engines. As is well known, piston-cooling devices always give rise to difficulties sooner or later, so that their elimination is of much importance and is, in fact, stipulated in many cases.

Engines with precombustion-chamber fuel injection have been equipped in several instances with exhaust-gas turbo-charging. For example, a Daimler-Benz, six-cylinder engine which develops 180 bhp at 1500 rpm has been so equipped.

Airplane Engines

The use of exhaust-gas turboblowers with airplane engines has already been made in various cases, first of all with gasoline engines. But in engines working with carburetors, no scavenging of the working cylinders is possible; the increased output attained is therefore small, and the temperatures before the turbine become so high as to cause many difficulties. The Büchi exhaust-gas turbo-charging in combination with mechanical gasoline injection, whether into the suction manifold of the engine, or into the working cylinders themselves, allows these engines to be scavenged efficiently. It is merely necessary to take care that the gasoline injection begins after the scavenging, with precompressed fresh air, has been completed. If this is the case, the Büchi system of exhaust-gas turbo-charging can be adapted to gasoline-driven airplane engines and will give the same advantages as in Diesel engines. It can of course be used with Diesel airplane engines without any special considerations.

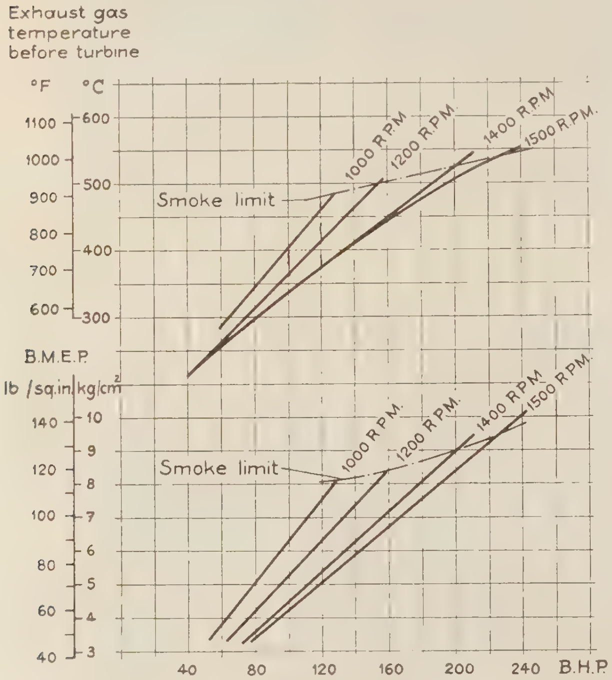


Fig. 12 Exhaust Temperatures and Brake Mean Effective Pressures at Various Loads and Speeds Observed During the Tests of 225-Bhp Six-Cylinder Saurer Diesel Engine Equipped With Exhaust-Gas Turboblower

For obvious reasons, it is not possible at present to give any particulars concerning the adoption of the Büchi system of exhaust-gas turbo-charging to airplane engines. It is, however, a most effective means of compensating, up to the greatest altitudes, for the loss of output caused by the rarefied air. It can also be used to increase the output near the ground level considerably, so that the climbing speed of the airplane becomes greater. The reduced fuel consumption obtained by adopting this system is also of great importance when flying long distances.

Two-Cycle Internal-Combustion Engines

The Büchi exhaust turbo-charging can be used also with two-cycle Diesel engines. Tests in connection with this type of engine have already been made and will be continued. Because of the lower temperatures of the exhaust gases, the results obtained by adopting this system depend greatly on the size and design of the engine in question. However, by adopting special methods of carrying out the charging and scavenging processes, an appreciable increase in output can be obtained.

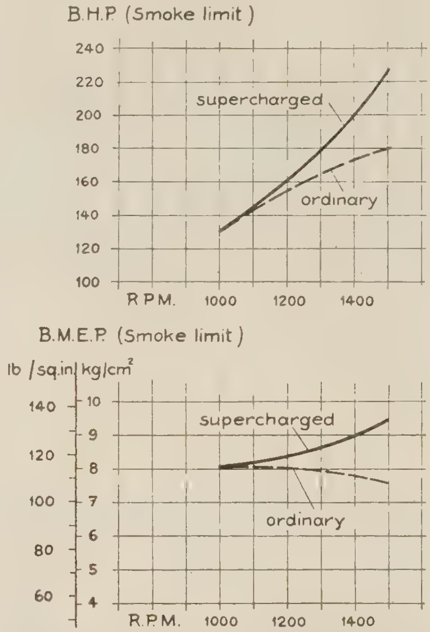


Fig. 13 Variations of Brake Horsepower and Brake Mean Effective Pressures at Various Speeds of a 225-Bhp Six-Cylinder Saurer Turbo-Charged Diesel Engine

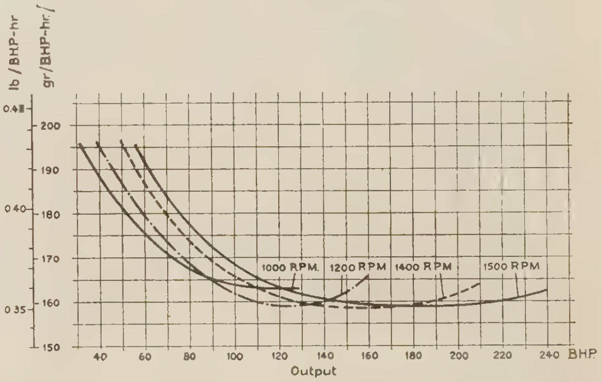


Fig. 14 Fuel Consumption at Different Speeds of a 225-Bhp Turbo-Charged Diesel Engine

Gas Engines

In addition to the engines previously described which work with liquid fuel, gas engines may also be supercharged by blowers driven by the exhaust gases and some installations have already been made. In order that the cylinder may be scavenged, it is

necessary (just as with engines working with gasoline), that the fuel, i.e., the gas, should be admitted only after the scavenging period has terminated.

Air Charging Blowers Driven by Exhaust-Gas Turbines

A section through a vertical blower built by Brown, Boveri & Company, is shown in Fig. 15. This is a single-stage blower, driven by a single-stage turbine, and is the type usually adopted today. Two-stage blowers are used for higher supercharging, especially to compensate for higher altitudes. The runner is

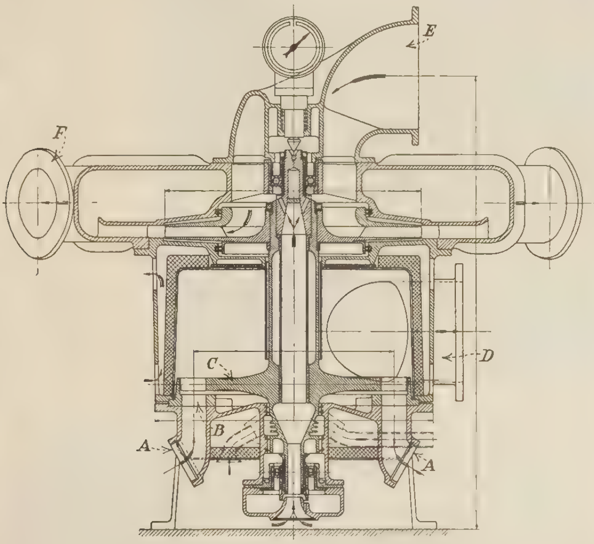


Fig. 15 Section Through Brown, Boveri Vertical Exhaust-Gas Turboblower

runner, with the turbine wheel to the left and the blower impeller to the right. Below, to the left can be seen the admission nozzle ring for the turbine, and to the right the diffuser for the blower.

These blower sets are small in comparison with the internal-

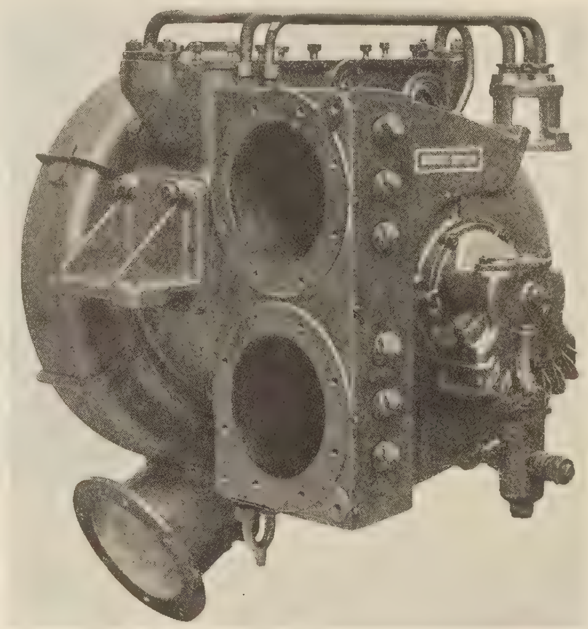


Fig. 16 Turbine End of a Horizontal Brown, Boveri Exhaust-Gas Turboblower With Water-Cooled Turbine Casing

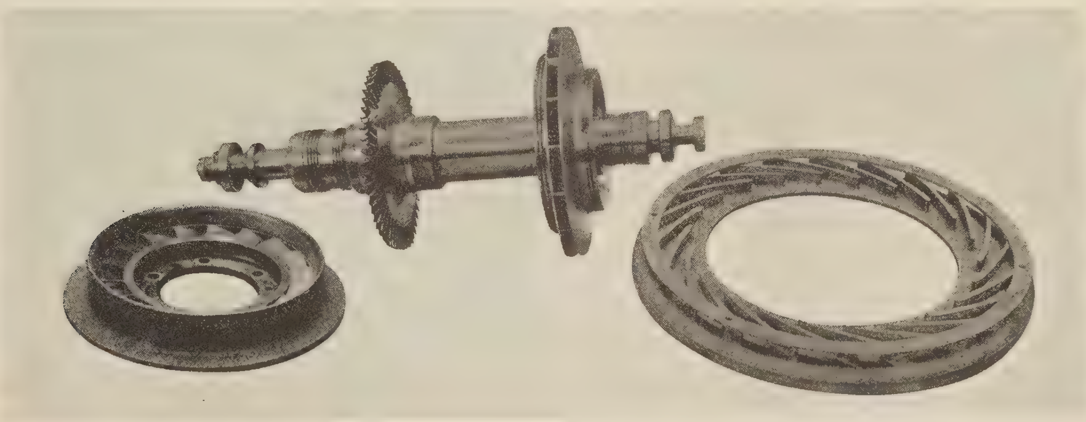


Fig. 17 Runner, Turbine-Nozzle Ring, and Blower Diffuser of a Brown, Boveri Exhaust-Gas Turboblower

carried outside in ball bearings. The exhaust gases enter at A and pass through the nozzle ring B to the turbine blading of the runner C. At D the exhaust gases leave the turbine. The charging air enters at E and leaves at F.

A view of a horizontal blower, seen from the turbine end, is given in Fig. 16. It can be seen that the turbine has two separate inlets for the exhaust gases. The sealing air is led through a pipe from the delivery branch of the blower to the stuffing box of the exhaust-gas turbine. An air filter is fitted at the inlet end of the blower. In Fig. 17 the three most important parts of such a set can be seen in detail. Above, in the center, is the

combustion engines and they can, as already mentioned, be very conveniently mounted, since they generally require no particular room, but can be located in any available free space. Their weight is also low, particularly in the type used for high-speed engines for airplane and traction purposes. For a 500- to 1000-hp airplane engine it is possible to build an exhaust-gas turboblower weighing approximately 100 to 150 lb. Naturally, light metals must be extensively employed.

Many exhaust-gas turboblowers have been built for engines developing up to 6000 bhp. Such a blower is shown in Fig. 18. This was built by Harland & Wolff, Belfast, and has four separate

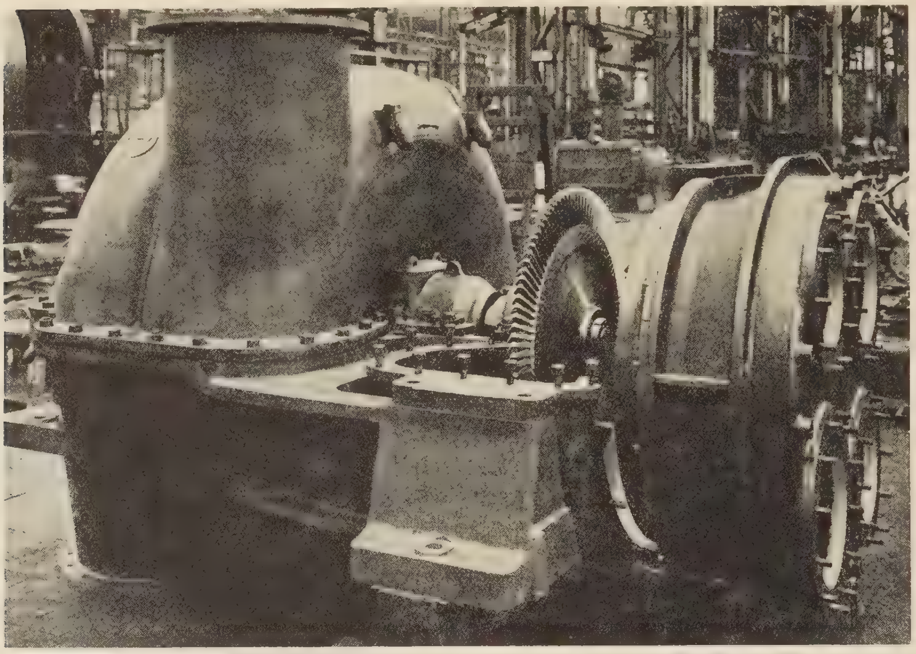


Fig. 18 Exhaust-Gas Turboblower for 6000-Bhp Diesel Engines

gas inlets to the turbine, since it works in connection with a ten-cylinder Diesel engine. On the other hand, however, exhaust-gas turbo-charging has also been adopted for very small engines; it will be interesting to note that Brown, Boveri & Company have already built blowers for 80-hp engines giving them a supercharged continuous output of 120 bhp.

Some Particular Features of the Büchi Exhaust Turbo-Charging System

Behavior When Starting and When Suddenly Loading the Engine. In Fig. 19, the speed of the engine and blower, and also the output of the engine, are plotted as functions of the starting time. The results were obtained with a 1000-bhp Diesel engine, started in the cold state at no load and run idle up to normal speed. A 12-sec period was required for this starting. The engine was then put on load at once by suddenly cutting in the generator which it was driving. It can be seen that the normal output of 1000 bhp was reached in 13 sec from idling. When starting, the speed of the charging blower was brought up to 4800 rpm at no load. The time required to attain its normal speed of 10,200 rpm at full output of the engine was somewhat more than 13 sec. Nevertheless, it can be seen from Fig. 19 that the charging blower is accelerated very quickly—in fact, almost instantaneously—when load is thrown on the engine. The reason for this is that the rotors of the turbine and blower are extremely light and frictional resistance is very low, due to their being carried in two roller bearings.

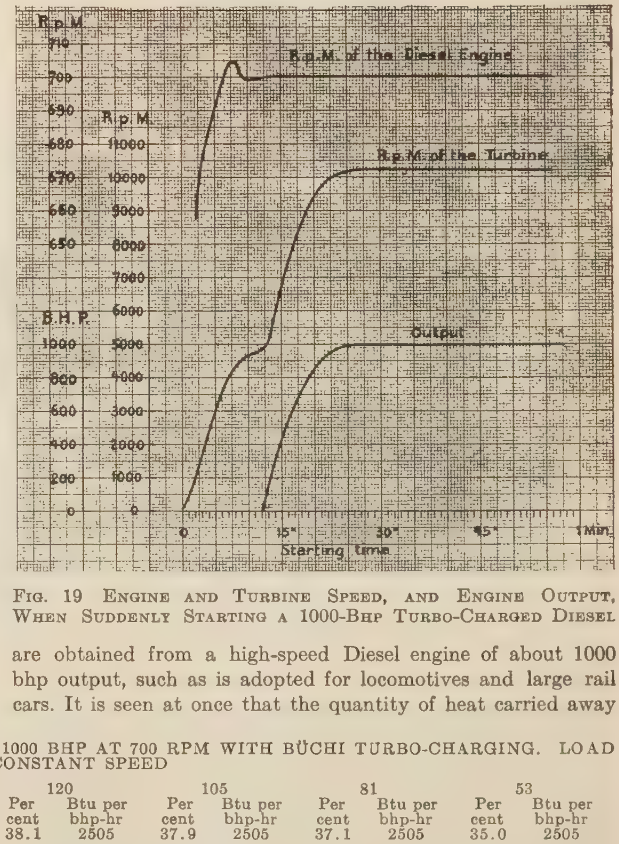


Fig. 19 Engine and Turbine Speed, and Engine Output, When Suddenly Starting a 1000-Bhp Turbo-Charged Diesel

Heat Balance. A heat balance is given in Table 1. The figures are obtained from a high-speed Diesel engine of about 1000 bhp output, such as is adopted for locomotives and large rail cars. It is seen at once that the quantity of heat carried away

TABLE 1 HEAT BALANCE OF A DIESEL ENGINE DEVELOPING 1000 BHP AT 700 RPM WITH BÜCHI TURBO-CHARGING. LOAD VARYING WITH CONSTANT SPEED

Brake mean effective pressure, lb sq in.	120		105		81		53	
Heat Balance	Per cent	Btu per bhp-hr	Per cent	Btu per bhp-hr	Per cent	Btu per bhp-hr	Per cent	Btu per bhp-hr
Effective work	38.1	2505	37.9	2505	37.1	2505	35.0	2505
Heat losses:								
Cooling water for engine	16.1	1057	16.2	1072	17.2	1168	17.0	1210
Cooling water for oil-cooler	2.3	151	2.6	171	3.1	210	4.1	294
Cooling water for turbine	2.2	143	2.3	151	2.0	135	1.7	123
Heat in exhaust gases after turbine	36.6	2415	34.9	2315	35.6	2405	34.1	2445
Other heat losses	4.7	322	6.1	417	5.0	342	8.1	583
Total heat introduced with the fuel per bhp-hr	100.0	6593	100.0	6631	100.0	6765	100.0	7160

in the cooling water per brake horsepower-hour is much less than in an ordinary Diesel engine working without supercharging. With this engine it is assumed that a water-cooled exhaust-gas turbine is used. Water cooling is recommended for large exhaust-gas turbines, i.e., when they are not limited in weight as those used for small high-speed engines and airplane engines. The heat loss for cooling the turbine is very small; little more than 2 per cent of the heat introduced into the engine. Also in the oil cooler of the engine, only 2.3 to 4.1 per cent is carried away, depending on the load. This quantity of heat is a direct measure of the work done in overcoming friction in the supercharged engine, which friction is again responsible for wear in the engine. About 36.6 to 34.1 per cent of the heat passes away in the exhaust from the turbine.

The figures given allow conclusions to be drawn regarding the dimensions required for the coolers for cooling water and lubricating oil and regarding possible further utilization of the heat in the exhaust gases.

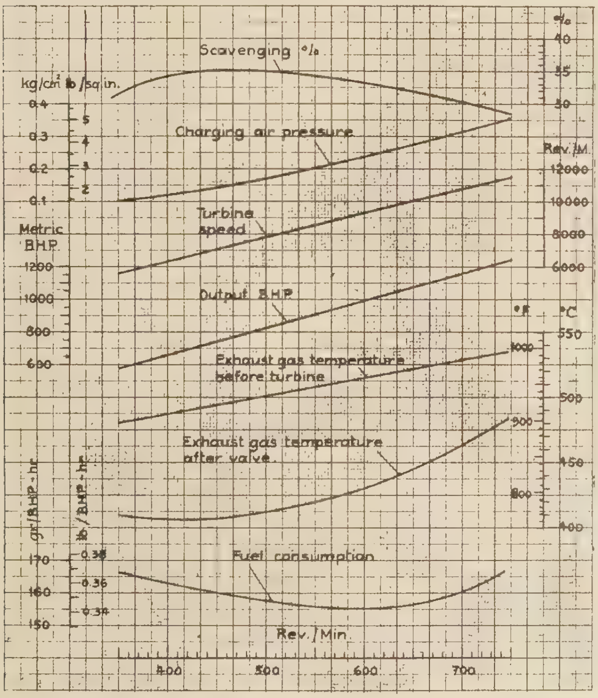


Fig. 20 Test Results When Running a Turbo-Charged Diesel Engine Under Constant Torque but at Different Speeds

Behavior With Variable Speed and Constant Torque of the Engine

Fig. 20 shows the conditions when the engine was working constantly with a mean effective pressure of 132 lb per sq in. with the speed varying from 750 to 350 rpm. Fig. 20 shows that, as the speed decreases, the fuel consumption per brake horsepower-hour and the temperatures after the exhaust valves and ahead of the turbine fall to a certain minimum. This minimum for the fuel consumption is 0.342 lb per bhp-hr, while the temperatures reach their minimum at 420 rpm. The speed of the turbine falls linearly as also does the charging pressure after the blower. The pressure has a tendency to fall less at speeds under 400 rpm (which are very low for the engine), since the temperature of the exhaust gases then increases as a result of increased fuel consumption.

We see, therefore, that a supercharged engine can maintain the normal torque down to a greatly reduced speed, without the temperatures and fuel consumption attaining excessive values. This fact depends on the time area for the passage of scavenging air. In spite of the falling charging pressure it is possible to maintain the same temperature conditions down to about 40 to 45 per cent of maximum speed. As tests have shown, the same holds also for comparatively slow-running stationary and marine engines.

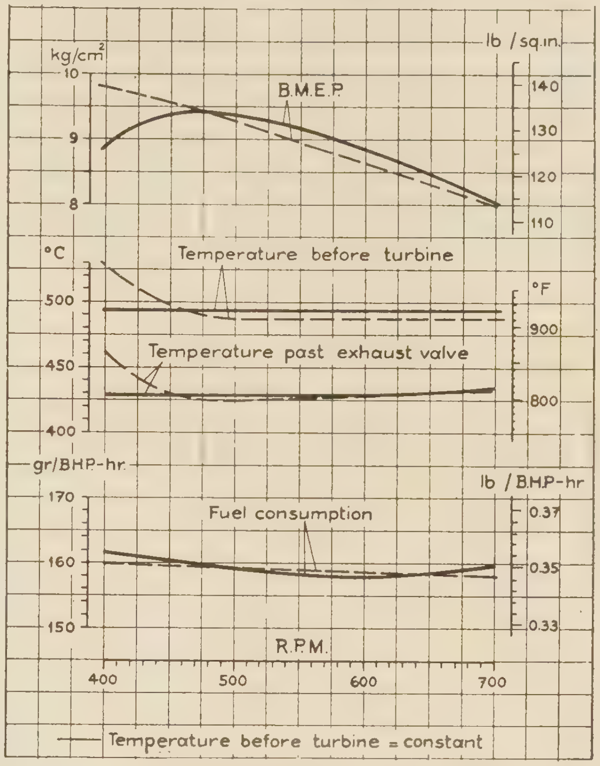


Fig. 21 Test Results When Running a Turbo-Charged Diesel Engine With Constant and Slightly Increasing Exhaust Temperatures at Different Speeds

Torque Obtainable With Constant Exhaust Temperatures and Variable Speed

Fig. 21 shows that when reducing from maximum speed to under 70 per cent and maintaining the same exhaust-gas temperatures, the torque can be increased by about 18 per cent. It is evident that exhaust-gas turbo-charging provides very favorable conditions. These conditions are particularly important for traction engines, where the speed of the engine falls when taking a gradient or when accelerating. If the torque of the engine can be increased as shown, the acceleration of the vehicle and the taking of gradients will be facilitated.

Conditions are also illustrated in Fig. 21 for a certain rise of exhaust temperatures with decreasing speed of the engine. As can be seen, the torque can be increased by about 23 per cent when reducing from 700 to 400 rpm.

Influences of the Automatic Change in the Charging-Air Pressure

Exhaust-gas turbo-charging provides an advantage in that the charging compressor is not coupled to the internal-combustion

engine, also, that it adjusts itself independently of the engine. It runs at different speeds, depending on the load of engine. When starting, and when speed or load of engine is low, practically no charging pressure is produced. Consequently, no adverse influence will be exerted, as for example in the case of charging blowers mechanically coupled to the engine. When starting, and at low loads, the latter require the same power to drive them as at high loads. Mechanically driven blowers therefore cause a very high fuel consumption at low loads. If the blower is taken out of service, complicated clutch couplings must be provided. On the other hand, with exhaust-gas turbo-charging, the charging pressure varies and increases when the load or the speed of the engine increases. This is of special importance for overload conditions. If such an engine is overloaded, for example by 20 per cent, the quantity of air introduced into the engine will also be increased by at least 10 per cent because the charging pressure is automatically increased. The increase in load on the engine is in reality only 10 per cent, in respect to the weight of air available. This is also the reason why the fuel consumption and the exhaust-gas temperatures do not rise so quickly in the overload period as in ordinary engines without exhaust-gas turbo-charging or with mechanically driven blowers. It must be remembered that, as shown in Fig. 3, the quantity of scavenging air is also increased.

Other points in connection with exhaust turbo-charging could be mentioned. It ought, however, still to be noted, that because of the much smaller moving masses in a supercharged engine, the inertia effect of the masses is much reduced. A further important point, particularly for high-speed and multicylinder engines, is that the broadening of the indicator diagrams of the working cylinders (which is equivalent to less pronounced changes in pressure) means less pronounced torsional oscillations in the crankshaft, the amplitudes being reduced to one half or less of those in ordinary Diesel engines with acute indicator diagrams.

Performance of Lubricants Based on Diesel-Engine Service Conditions

By C. M. Larson,[1] New York, N. Y.

The author discusses the effects of Diesel-engine design and operating conditions on the performance of lubricants used in these engines. He presents charts which can be used to select the proper lubricant for definite operating conditions of Diesel engines, and gives an example showing how to use one of the charts.

In judging the performance of lubricants used in solid-injection Diesel engines, there are certain definite designs and operating conditions imposed on the lubricant which have to be considered. It is necessary, therefore, to take current design requirements and study the service effects on the lubricating oil. The lubricating system of today is of the dry sump type, one pump circulating oil to the bearings and cylinders and another suction pump returning the oil to the supply tank. The same oil, therefore, lubricates the bearings and the power cylinders.

First consider how the viscosities of lubricating oils are being classified by various Diesel-engine manufacturers. In the majority of designs, the viscosity requirements are 400 to 780 sec Saybolt Universal at 100 F, as shown by area *A* in Fig. 1. Winton, however, is restricting their circulating oils to area *B*, which is limited by 1000 sec viscosity at 100 F maximum, and 75 sec at 210 F minimum.

The oils covered by area *A* consist of those ranging from Gulf Coast, through Mid-Continent, Mid-Continent solvent-treated, to Pennsylvania, while area *B* is comprised of selected Mid-Continent, Mid-Continent solvent-treated, Pennsylvania, and Pennsylvania solvent-treated oils. Winton leans toward the use of Pennsylvania oil of 85 to 95 sec viscosity at 210 F, with the 1000 sec viscosity at 100 F maximum maintained.

Fig. 2 shows the most modern design of the Hooven, Owens, Rentschler double-acting, four-stroke-cycle Diesel engine, for which is specified oils having a viscosity of 450 to 550 sec at 100 F. This Diesel engine was tested and accepted using a Gulf Coast oil of 500 sec Saybolt Universal viscosity at 100 F, which oil falls in zone 7 of Fig. 1.

Fig. 3 shows the Winton two-stroke-cycle Diesel engine tested using a Pennsylvania oil with a viscosity of 85 sec at 210 F, which oil falls in zone 1 of Fig. 1.

Atlas Method of Selecting Lubricating Oils

One of the most complete methods for the selection of the grade or viscosity of the oil for various types of service and temperature conditions, without respect to quality, is the lubrication chart shown in Fig. 4. This chart was developed by the Atlas Imperial Diesel Engine Company. The selection of the lubricating-oil quality is left to the customer or the oil-company engineer who is acquainted with the actual operating conditions.

The margin of the chart adjacent to the temperature-difference values has been arranged in zones, with subzones *A*, *B*, and *C* which are used in conjunction with the engine-room temperature for indicating the proper oil grades. The various S.A.E. numbers or grades with corresponding viscosities appear as diagonal bands across the chart and have been correlated with the other values to insure the selection of an oil with the correct viscosity for the conditions encountered. Engine recommendation sheets, similar to Table 1, are used by Atlas Imperial Diesel Engine Company to furnish complete engine data including the speed on which the oil recommendations are based and the proper zone in which the engine is located for the conditions indicated. Standard Atlas engines are not equipped with oil coolers and are assumed to be supplied with cooling water at the average temperature found in practice. Stationary and industrial-engine sheets, as shown by Table 1, include zone recommendations for radiator cooling systems, in which case it is assumed no oil cooler is employed. Intermittent duty covers engines operating at intermittent loads and speeds, such as found in installations in power shovels, draglines, locomotives and power units. Table 1 lists various models of Atlas engines and shows the lubrication zones in which each standard engine, and standard engines with oil coolers and radiator cooling systems, are located. The recommended lubrication zone is based on the operation of the engine at continuous load and speed, except where specifically indicated otherwise. The lubrication zones are definitely defined for each engine under the conditions specified in the engine recommendation sheets.

TABLE 1 STATIONARY FOUR-CYCLE ATLAS DIESEL ENGINES AND LUBRICATING ZONES IN WHICH THEY ARE LOCATED

Engine characteristics						Lubricating-zone classification			
							Special oil cooler (accessory)	Radiator cooling system	
Model no.	Hp	Cylinders	Bore, in.	Stroke, in.	Speed, rpm	Standard engine		Maximum duty	Intermittent duty
4ES327	80	4	7	8.5	650	3*A*	1*B*	3*B*	3*A*
6ES327	120	6	7	8.5	650	3*A*	1*B*	3*B*	3*A*
3HS1021	105	3	10	13.0	360	2*B*	1*B*	2*C*	2*B*
4HS1021	140	4	10	13.0	360	2*B*	1*B*	2*C*	2*B*
6HS1021	210	6	10	13.0	360	2*C*	1*B*	3*A*	2*C*

In selecting the proper grade of lubricating oil for a given engine, first secure the correct zone from the recommendation sheets. Knowing the engine-room temperature, the S.A.E. number can be found from Fig. 4 by locating the intersection of the vertical temperature lines with the horizontal zone. If the oil temperature to the bearings is known or can be determined, the S.A.E. number may be selected from this temperature alone since the oil-temperature lines are parallel to the grade bands.

---

[1] Supervising Engineer, Sinclair Refining Company, New York, N. Y. Mem. A.S.M.E. Mr. Larson received the degree of B.S. in M.E. from Armour Institute of Technology in 1913. He became lubrication engineer with the Texas Company in Chicago, and was advanced to the position of chief engineer in charge of lubrication-service engineers, comparative tests, lubrication-equipment installation, and development of new products. He served as wing lubrication officer, first lieutenant, Air Service, U. S. Army. In 1919 he joined the Sinclair Refining Company as assistant supervising engineer and became supervising engineer in 1921.

Contributed by the Oil and Gas Power Division and presented at the National Oil and Gas Power Meeting of The American Society of Mechanical Engineers held at Ann Arbor, Mich., June 24 to 27, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until April 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

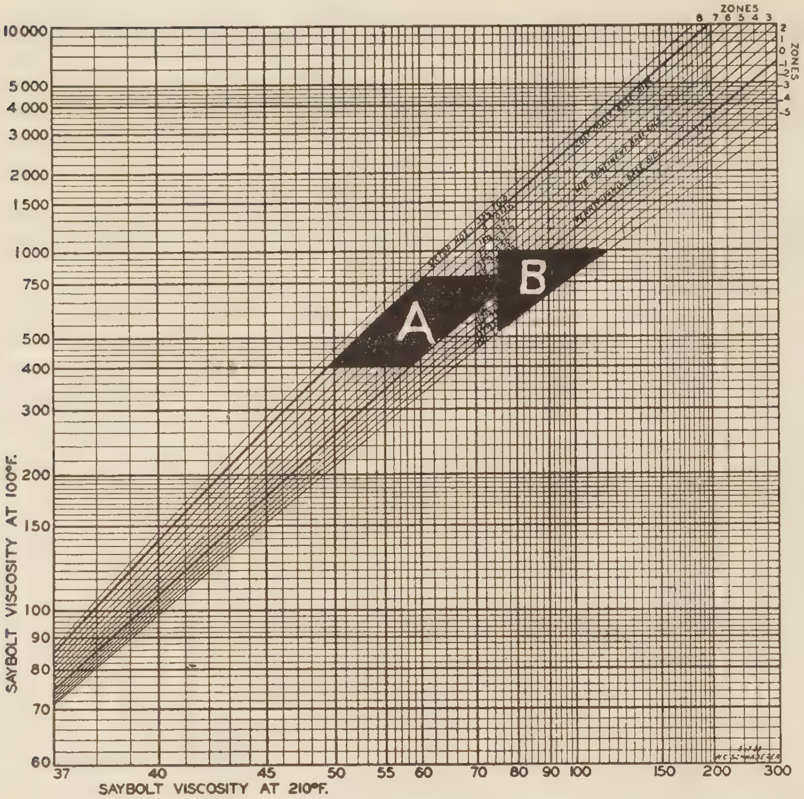


Fig. 1 Straight-Line Viscosity-Zone Index Chart

Wherever possible the S.A.E. number should be selected on the basis of the oil temperature to the bearings, although in the majority of installations it will be difficult or impractical to determine this temperature, and the grade must of necessity be selected on the basis of the lubrication zone and the engine-room temperature. When an accessory oil cooler (not manufactured by Atlas Imperial Diesel Engine Company) is incorporated in the engine lubrication system and the oil temperature is unknown, it will usually be safe to assume the temperature to be 10 to 15 F above the water inlet temperature to the cooler. An oil of a given S.A.E. number may be safely used at temperatures 10 F above and below its boundary on the chart. In case of doubt, it is advisable to use a heavy rather than a light lubricating oil.

As an example, select the proper grade of lubricating oil for a Standard Atlas Model 6ES327, 120-hp, six-cylinder, $7 \times 8^1/_2$-in., 650-rpm stationary engine, operating at an engine-room temperature of 80 F. It is seen from Table 1 that an oil falling in zone 3*A* should be used with this engine. Referring to Fig. 4 the intersection of zone 3*A* and the vertical 80-F line indicates an S.A.E. number of 50. An S.A.E. 50 oil may be safely used in engine-room temperatures of 40 to 100 F.

Effects of Operating Conditions on Lubricating Oils

In circulating systems, oil escapes from the bearings and is whipped into a fine spray. The hotter the oil and the more it is whipped into the hot air or blowby gases, the greater the oxidation and sludging of the oil. The rate of oil circulation and capacity of the system regulates the amounts of heat absorbed or removed. Naturally, an engine, with a rated capacity of 1 gal per 6 hp, with the same rate of circulation and operating conditions, will impose less hardship on the oil than the same engine with a capacity of 1 gal per 10 hp. In several instances, where it was impossible to increase oil capacity, excessive sludge trouble was eliminated by increasing the rate of circulation and installing an oil cooler. The increased rate of circulation of cooler oil reduced the piston and ring temperatures so that less oxidation and cracking of the oil occurred and the blowby was reduced because a better piston seal was maintained. Formerly, heavier oils were tried but the condition became worse because of the higher temperatures and the more sluggish oil flow.

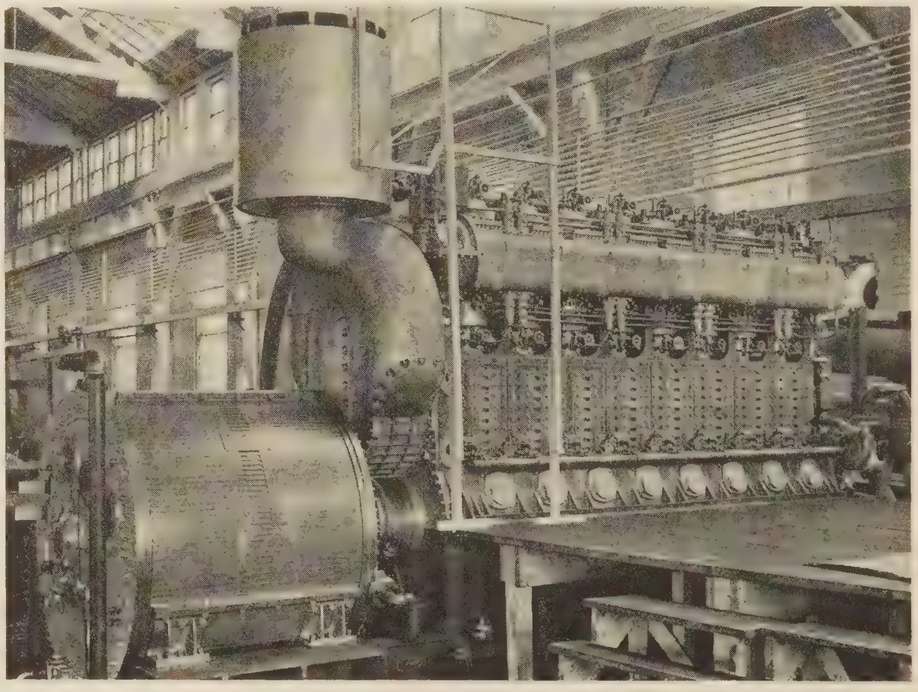


Fig. 2 Modern Hooven, Owens, Rentschler Double-Acting Four-Cycle Diesel Engine

High end-point, high carbon content, or low ignition quality in a fuel has a great deal to do with excessive sludge in the lubricating oil. This is due to slow or faulty combustion and cracking of the heavy ends.

Fig. 5, showing a plot of spontaneous-ignition temperature against the average boiling point of different fractions of petroleum oil, indicates theoretically the drastic change in characteristics of the heavy fractions of a petroleum distillate at different ignition temperatures. The sharp turn of the curve at 700 F indicates that such fractions do not burn completely, and that they crack into fine carbon which blows by the pistons into the circulating oil.

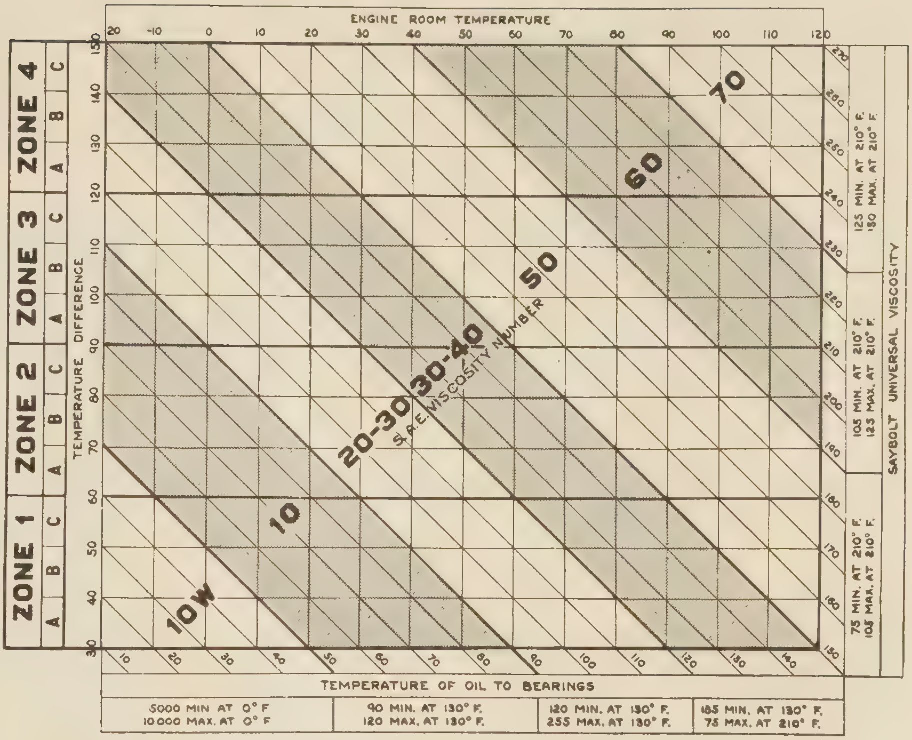


Fig. 4 Lubrication Chart Developed by the Atlas Imperial Diesel Engine Company

In addition to this, consider the high pressure shown in Fig. 6*d* that was caused by a fuel with poor ignition qualities. The fuel had a cetane number of 31. It caused rough running, and raised the maximum pressure to 1059 lb per sq in. at full load, or 262 lb per sq in. higher than the maximum pressure shown in Fig. 6*b*, which was attained with a fuel having a cetane number of 57. The part-load maximum pressure of 862 lb per sq in. attained by the fuel with a low cetane number and shown in Fig. 6*c* was also greater than the full-load pressure of 797 lb per sq in. attained with the better grade of fuel and shown in Fig. 6*b*. Because of these high pressures attained with low-quality rough-running fuel, the blowby with such a fuel is increased considerably, and where this condition is coupled with high end-point, much soot passes the piston rings into the crankcase. Where the shocks were too great because of high pressures attained with low-quality fuels, the bearings have been known to pound out.

An analysis of a circulating oil, complained of as giving bearing trouble, showed by the volume method that it contained 98.5 per cent oil, and 1.5 per cent sludge. When the oil was separated completely by a 6000-rpm centrifuge,[2] it virtually reverted to its original state, showing a viscosity of 520 sec at 100 F; a viscosity of 56 sec at 210 F, a neutralization number of 0.13 mg KOH; no precipitation number; a carbon residue of 0.10, and no ash content. However, an analysis of the 1.5 per cent sludge revealed that it contained 10.33 per cent oxidized oil (asphaltic) by weight, 8.8 per cent iron oxide, 11.37 per cent iron sulphide, 69.5 per cent carbon (piston blowby), and that it had an acid reaction to water.

The examination of the fuel showed that the sludge was

[2] "Lubricating Oil—General Information, Requirements and Methods of Test," Bulletin N. Eng. 31, 1936, Bureau of Engineering, U. S. Government Printing Office, Washington, D. C.

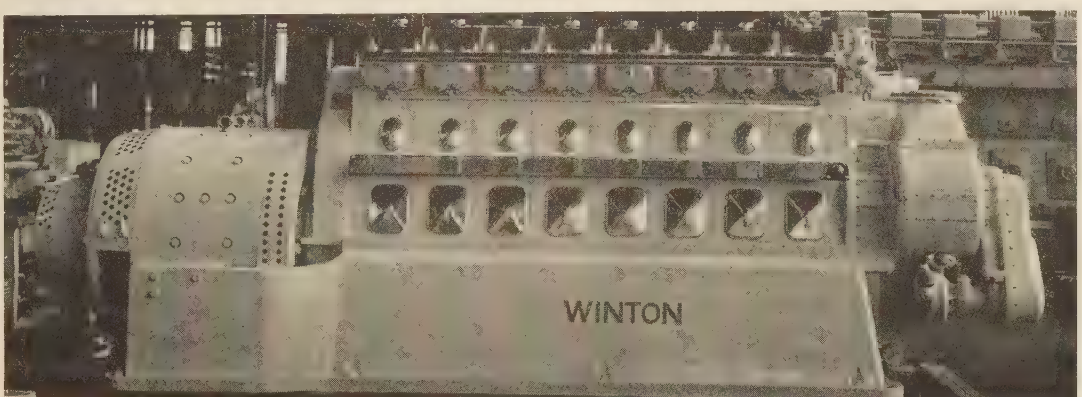


Fig. 3 Winton Two-Cycle Diesel Engine

caused by the 730 end-point and 37 cetane number, and that the high acid and iron sulphide were caused by the high sulphur content of 1.51 per cent in the fuel. When the fuel was changed to a 600-end-point product with a low sulphur content of 0.25 per cent and a 55 cetane number (the engine operating at 900 rpm) the bearing trouble disappeared and the sludge condition was greatly reduced even though the drainage periods were greatly extended.

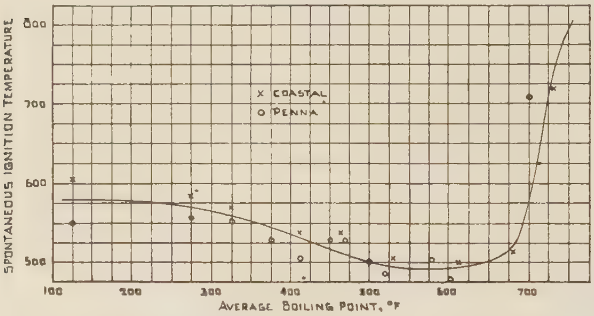


FIG. 5 EFFECT OF SPONTANEOUS-IGNITION TEMPERATURES ON GULF COAST AND PENNSYLVANIA PETROLEUM DISTILLATES

The viscosity of the circulating oil increases with use due to oxidation. Dilution never occurs except where the fuel injection plungers are tied into the circulating oil system, and plunger leakage takes place.

Every precaution should be taken to prevent the entry of water into the circulating systems. Water in the oil not only increases the frictional resistance, causing the oil film to break down prematurely, but also corrodes the journals.

Excessive carbon deposits in piston-ring grooves interfere with the functioning of the rings. The rate of deposit varies with each particular engine. Carbon deposits of this nature can be reduced by preventing the aggregate of carbon from forming. This can be best accomplished by keeping the temperature of the pistons below the cracking point of the oil and allowing enough lubricating oil to pass the top ring to flush the blowby carbon

TABLE 2 WEAR OF LINER OF A DIESEL-ENGINE CYLINDE

Distance from top of piston, in.	Longitudinal wear per 1000 hr, in.	Transverse wear per 1000 hr, in.
1.3125	0.0025	0.0029
2.3125	0.0010	0.0014
6.7500	0.0008	0.0014
10.0000	0.0010	0.0014
12.7500	0.0004	0.0008

from the ring grooves. However, the high end-point of the fuel, which is slow-burning and cracks into fine sooty carbon and tarry matter, will increase the rate of ring sticking. In a few instances, where the temperature of the rings was high enough to crack the lubricating oil, or even where circulating-oil temperatures were extremely high, ring sticking was overcome by the addition of a small amount (2 per cent or less) of carbon-disintegrator material to the lubricating oil. This kept the carbon aggregate from building up into a briquette. It is too early to say how extended this additional agent will be used in large industrial Diesel engines.

Leakage of the gases past the split of each piston ring, and especially past the clearance between each ring and its groove, causes pressure to build up behind the rings. Behind the top ring this pressure is greatest, being approximately 100 per cent of the pressure on the piston. The pressure behind the second ring is approximately 80 per cent of the pressure on the piston. Behind the last ring it is practically negligible. The upper rings produce a squeezing action which greatly reduces the oil film. The lubricating film on the upper portion of the cylinder wall is subjected to higher temperatures for longer periods in addition to high ring pressures, and therefore this top portion of the cylinder wears the fastest. This is clearly shown by the measurements of a high-speed Diesel-engine liner given in Table 2.

Performance of lubricants in Diesel engines is so interrelated with combustion efficiency and lubricating-oil stability, that it is difficult to isolate them. However, in so far as the lubricating oil can be considered a contributing cause, if a lubricant is used which resists to the greatest degree possible any change in viscosity, carbon content and acid number during operation, then the user is assured that troublesome asphaltenes will not develop to cause sludging in the crankcase and sticking of piston rings and valves.

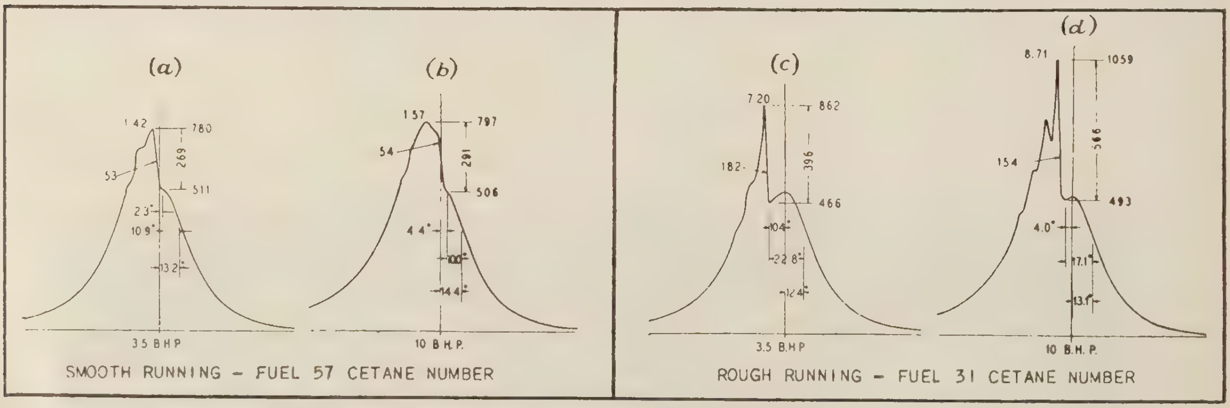


FIG. 6 DIESEL-ENGINE INDICATOR CARDS SHOWING THE EFFECTS OF TWO GRADES OF FUEL ON THE WORKING PRESSURES
(Cards taken on a single-cylinder four-cycle, 4 1/2 × 6-in., 1200-rpm, 10-hp Diesel engine.)

Rotary Drilling Rigs Operated by Internal-Combustion Engines

By D. M. MacCARGAR[1] and O. A. HAAS,[2] TULSA, OKLA.

The authors discuss the use of internal-combustion engines as prime movers for rotary drilling rigs. They show diagrammatically the advances made in the application of internal-combustion engines to rotary drilling, and the different methods of connecting the engines through mechanical and electrical means to the drilling equipment.

THE PRACTICAL advantages of the internal-combustion engine have led to its adoption as a prime mover for rotary drilling rigs. The basic reasons for their general acceptance are (1) a great saving in fuel costs when compared to steam-driven units, (2) an equal saving in water, and (3) their portability which shows up in the form of lessened transportation costs. It is the intention of the authors to show by means of line diagrams and sketches the evolution or the development of the use of internal-combustion engines for rotary drilling. This is to be accomplished by showing the different methods of connecting the engines through mechanical means to the drilling equipment, and later by showing the more flexible methods in which electric generators and motors are used as part of the drilling units.

In the following paragraphs wherever the designation "mechanical drive" is used in a description, it is to designate a rotary rig driving the machinery direct from internal-combustion engines using either V-belts, chains, or gears as power-transmission mediums. Where "electrical rig" is referred to, it will mean either a direct- or alternating-current rig with internal-combustion engines driving the generators and either direct- or alternating-current motors driving the machinery.

Certain definite requirements are necessary in the design of a mechanical rig. The most important of these is that the connection between the engine and the load be elastic in nature. To obtain the maximum efficiency and allow the driller to operate his engines at their best torque point, it is necessary that a sufficient number of speed changes be provided in the design. In direct-current electric drives, due to the inherent characteristics of the equipment, it is not necessary that much thought be given to the type of draw works or the speed changes available, although with alternating-current electric drives the condition is almost comparable with mechanical drives.

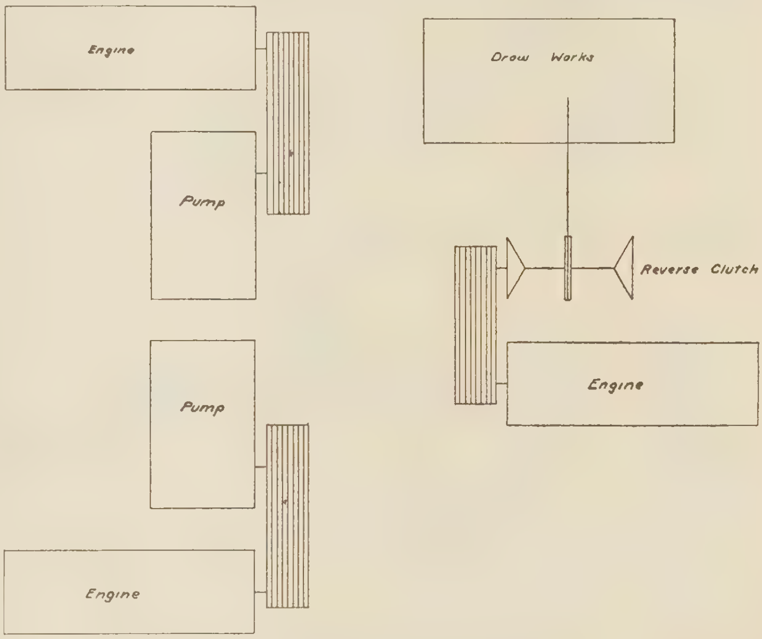


Fig. 1 First Successful Arrangement for Driving Rotary Drilling Rigs With Internal-Combustion Engines

Probably the first rotary rig driven by an internal-combustion engine, mechanically operated, was installed in California in 1924. Owing to the lack of knowledge in the design of proper reversing clutches, this rig was converted about a year later to a full direct-current electric drive. After a lull of about two years, during which time very little work was done on the design of rigs for rotary drilling driven by internal-combustion engines, an installation was made in 1927 of a mechanical rig in the Mid-Continent territory. This was probably the first successful rig of its type. A layout of this rig is shown in Fig. 1. In this layout it will be noted that the application of the engines to rotary-drilling equipment follows along the conventional line of steam practice; that is, an individual prime mover was provided for each pump and for the draw works. With this arrangement when engine trouble was encountered, particularly on the draw-works engine, it was necessary to halt the operations until the draw-works engine could be repaired or move one of the pump engines to the draw-works engine position. It might be well to note in passing, the prior attempts to connect in-

[1] District Manager, Allis-Chalmers Manufacturing Co. Mr. MacCargar was educated in Canada. He entered the employ of the Allis-Chalmers Company in Toronto in 1907, and with the exception of a period during the War and a short period on other work he has been associated with the Allis-Chalmers Manufacturing Company since that time. For the past fifteen years he has been active in the oil industry, specializing in drilling design and application of rotary drilling equipment.

[2] Chief Engineer, Oklahoma Iron Works and International Supply Company. Mr. Haas received the B.S. degree in 1926 and the M.S. degree in 1928 from the University of Wisconsin. He was employed as an engineer and sales engineer with the Allis-Chalmers Manufacturing Company for 21 years, but resigned in 1936 to assume his present position.

Contributed by the Petroleum Division and presented at the Semi-Annual Meeting of The American Society of Mechanical Engineers held at Dallas, Texas, June 15 to 19, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until April 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

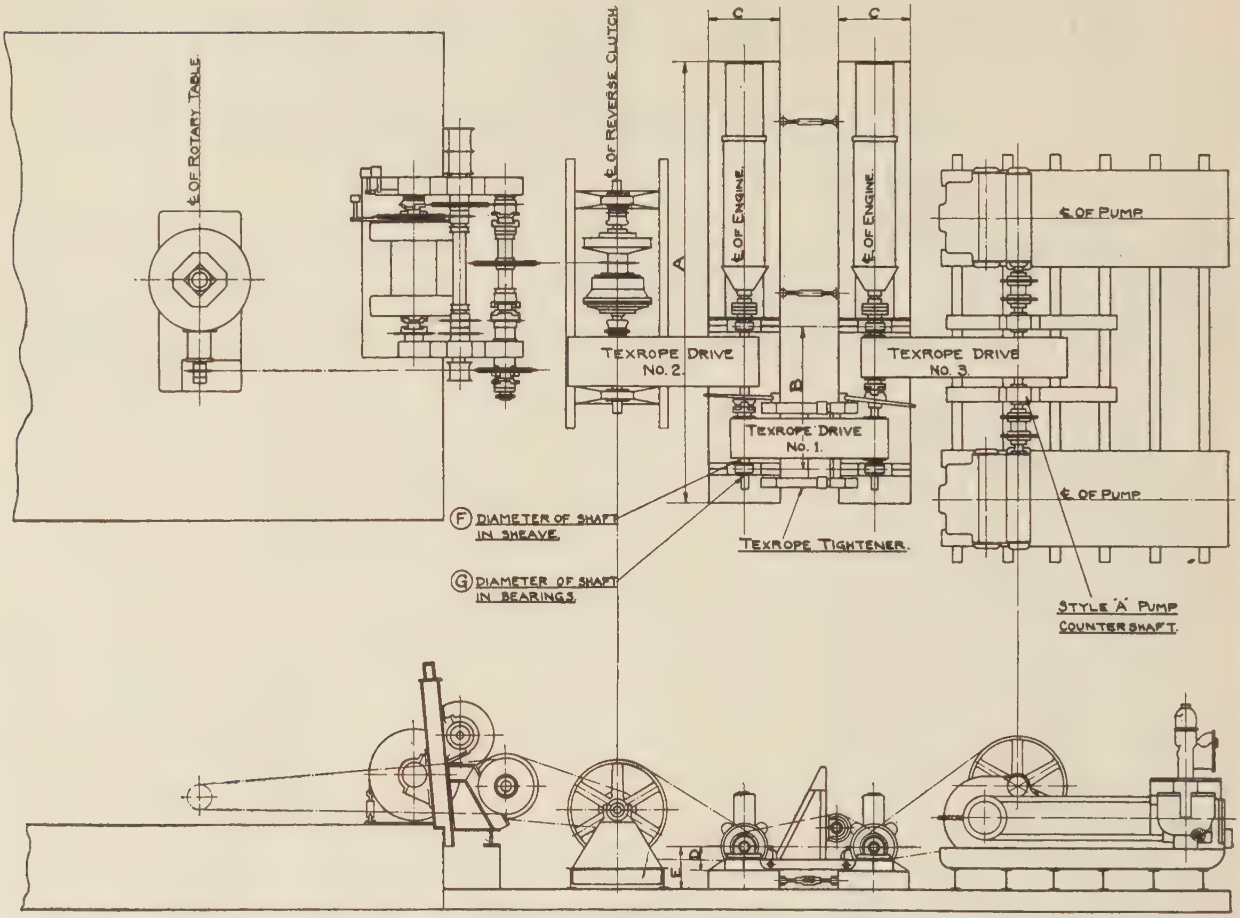


Fig. 2 Application of Internal-Combustion Engine to Rotary Drilling Rig for Eliminating Shutdowns Due to Failure of the Draw-Works Engine

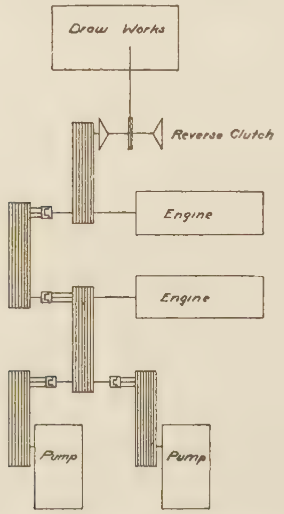


Fig. 3 A Modification of the Arrangement Shown in Fig. 2

ternal-combustion engines to the drilling equipment had employed the use of chains or gears. At the time this rig was designed, V-belt drives were coming into prominence and their use as a flexible power-transmitting medium was really a prime factor in the success of this rig. As stated before, the main objection to this rig was the danger of rig shutdowns from engine trouble and this gradually led to the development of the layout as shown in Fig. 2.

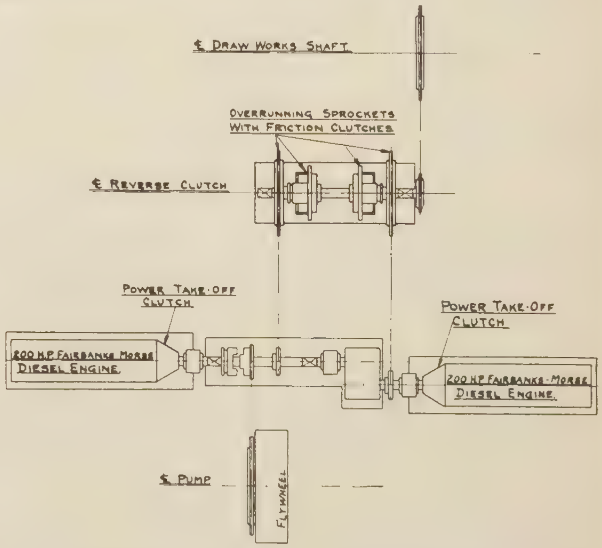


Fig. 4 Arrangement of Two Engines Face to Face to Provide Effective Reversing of the Draw Works

This mechanical drive provides the flexibility of either individual engine or combined engine operation by means of clutches arranged on the power stub shafts connected to the engine. Normal drilling operations are performed by one engine driving the draw works and table, while the other engine drives the pumps. For hoisting duty the two engines are compounded by means of clutches and the total power is then applied to the draw works. If either of the engines should be down, the other engine can continue the work by proper manipulation of the clutches. In some cases where the proper speed changes are not provided for on the draw works, correct drilling speeds may not be obtained when referred to a predetermined pump speed or vice versa, but conditions are so closely approximated that progress is not greatly hampered. There are many modifications of the installation shown in Fig. 2, one of which is shown in Fig. 3 which shows a different method of driving the pumps.

One of the major objections to the mechanical rig has been the complications introduced in the design of a good reliable reverse clutch. In most cases these clutches had to be designed with planetary or bevel gears. Fig. 4 shows a layout that utilizes

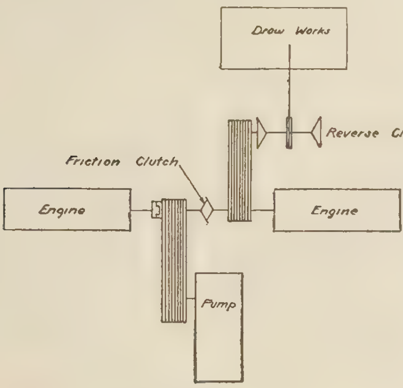


Fig. 5 Another Arrangement for Obtaining Effective Reversal of Draw Works

two shafts operating in opposite directions. To obtain the reversal on the clutch two engines are connected together face to face through a 1-to-1 gear arrangement. Opposite sides of the reverse mechanism are connected to opposite rotative shafts. It will be noted that provision is made for disconnecting the pump drive by means of a jaw clutch. Any of the methods shown in the preceding sketches for double pump drive could be used with this arrangement.

Apparently the wide use of the design shown in Fig. 4 led to the arrangement shown in Fig. 5. Here a right-hand and a left-hand engine are connected together by means of a friction clutch. Under ordinary operation the friction clutch is disengaged, one engine driving the pump and the other engine driving the draw works. It will be noted that there is a jaw clutch provided to disconnect the pump. For hoisting operations the friction clutch is engaged and the power of the two engines is used in multiple for hoisting.

There are a great many modifications possible in mechanical drilling rigs. These modifications are perhaps based on the availability of material, the connection of the designer, and the whim of the user. An example as to how far this can go is shown in Fig. 6 wherein a number of speeds are provided in the power-transmission mechanism, and in which both gears and chains are used. In the power transmission itself there are three speeds which means that with a four-speed draw works there would be twelve hoisting speeds and at least three drilling speeds.

As mentioned before, the limitations in torque characteristics

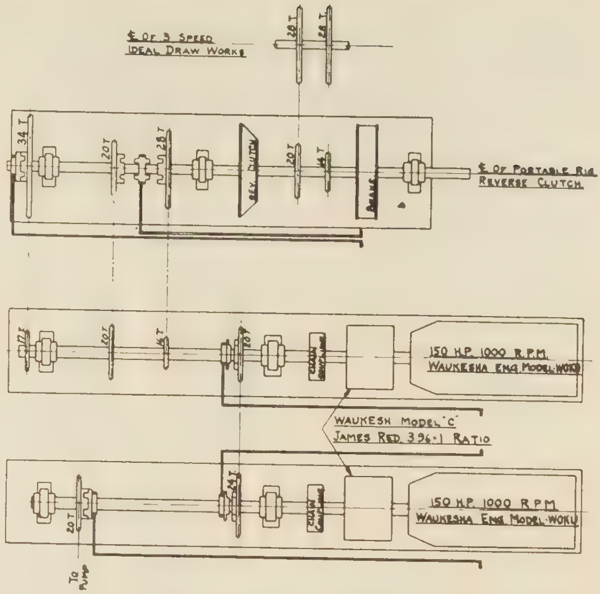
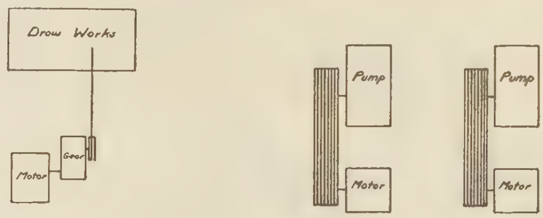


Fig. 6 Arrangement in Which a Number of Speeds Is Provided in the Power-Transmission Mechanism of Rotary Drilling Rigs



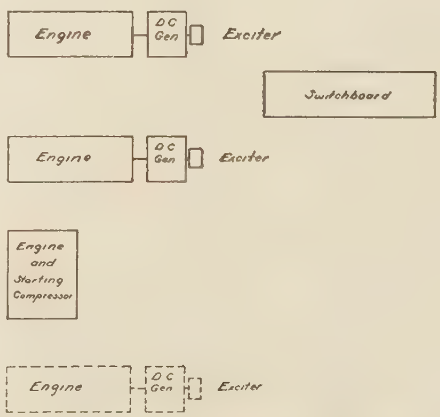


Fig. 7 Arrangement of First Direct-Current Equipment for Rotary Drilling Rigs

of internal-combustion engines at low speeds and their inability to handle shock loads led to the introduction of direct-current electric units as a transmission medium between the engines and the drilling equipment proper. On the first direct-current equipment built there was provided a direct-current generator

and a direct-current exciter direct-connected to each engine, and inasmuch as variable-voltage control or the Ward-Leonard system was used, if one engine broke down the whole drilling operation ceased, because it is necessary to have one generator for each motor. It is true that switching equipment was provided so that if one engine broke down it was possible to operate another engine for the hoisting operation to get the tools out of the hole. But still the drilling operation proper ceased until the drilling engine was back in service. This arrangement is shown in Fig. 7. The dotted lines show an improvement of the original development in which a reserve unit is provided with the improved scheme-switching equipment installed to allow any one of the engine units to be taken out and left out of service. It is apparent with this scheme that one of the three units is idle 100 per cent of the time, which means that there is an added investment for one reserve unit. As heretofore mentioned, most of the direct-current equipment in service today is based on the Ward-Leonard system of control, which means that a separate generator must be provided for each motor.

In drilling a well there are three distinct power requirements, as follows: (1) A variable-speed requirement for mud pump, (2) a variable-speed requirement for rotating the table, and (3) a heavy-duty hoisting operation. During ordinary drilling operations the first two are in use.

Limitations of the equipment shown in Fig. 7 led to the development of the arrangement shown in Fig. 8. The equipment shown in Fig. 8 includes one large and one small generator direct-connected to an engine; the small generator develops current for rotation and the large generator develops current for operating the slush pumps. Provision is made in the control for operating the two large generators together, either on the pump or on the

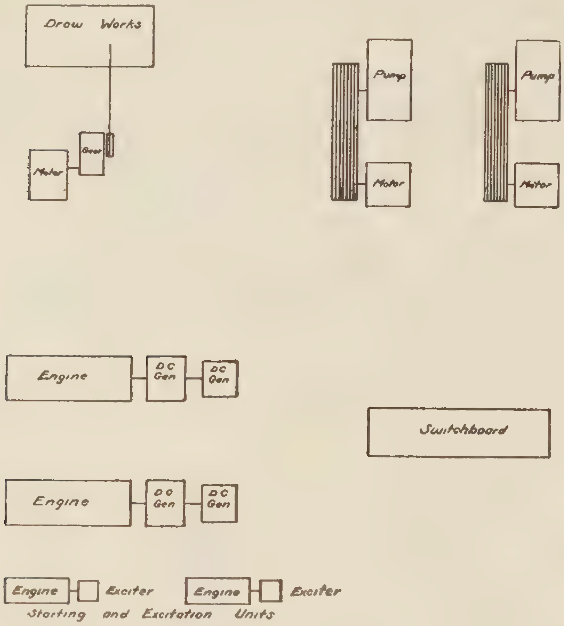


Fig. 8 Equipment Developed Because of Limitations of Arrangement Shown in Fig. 7

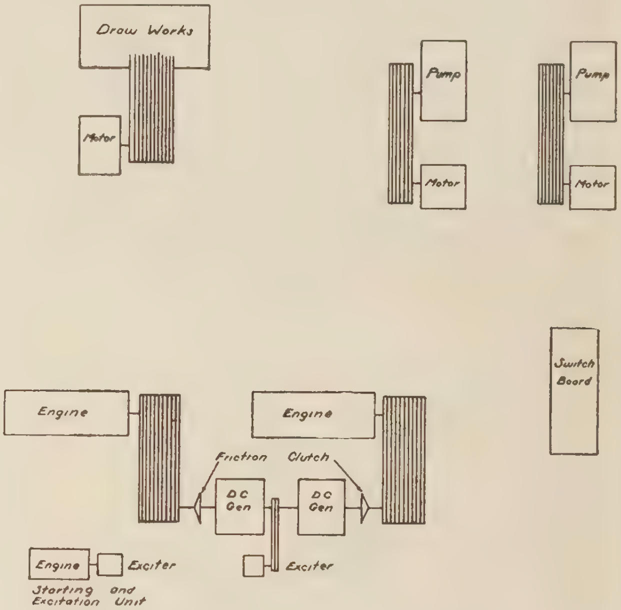


Fig. 10 Arrangement Permitting the Use of Engines of Any Speed With Stock Electrical Equipment

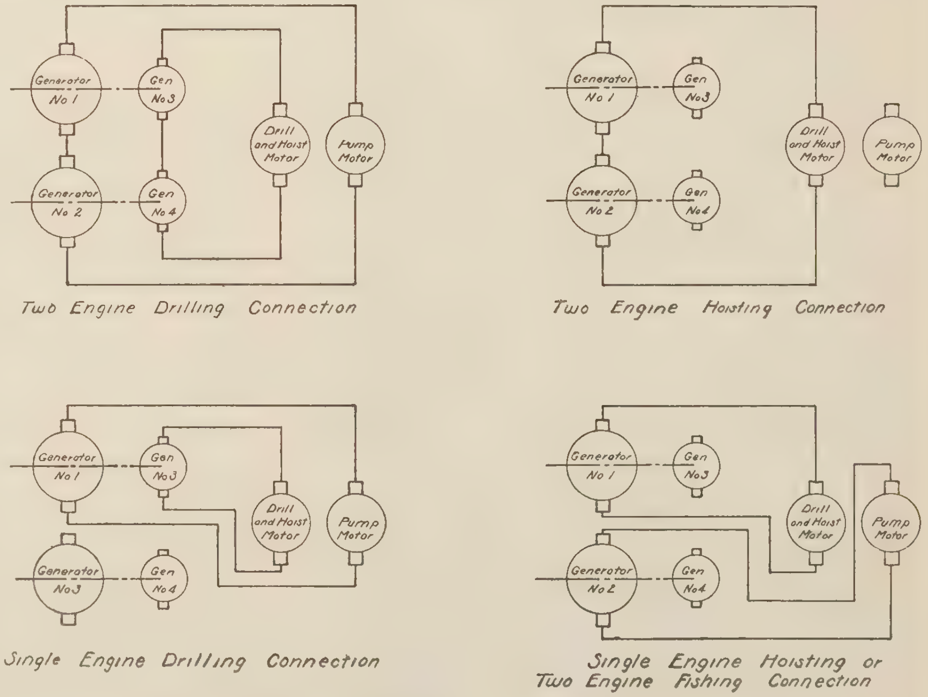
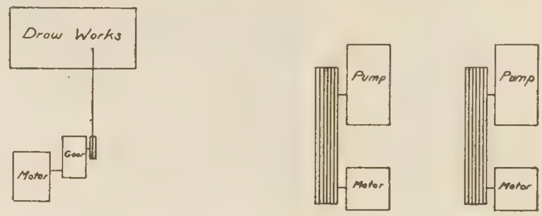


Fig. 9 Electrical Connections of Equipment Shown in Fig. 8

hoist, and the two small generators together for heavy-duty rotation. All operations are under full Ward-Leonard control. In this case if either engine breaks down the remaining engine can carry on the operations with full-speed control and with sufficient power to continue drilling without shutting down the operation. Most of the original units of this type were connected as shown in Fig. 9 in which the generators were run in series when both engines were in operation. Four different connections are shown. It will be noted that this is extremely flexible and all of the operations can be carried on with either one or two engines. Recently one manufacturer has offered a drilling unit which is identical with that shown in Fig. 8, with the exception that the generators are connected in parallel instead of series as shown in Fig. 9.

Because of the great range in ratings and speeds of the different types of Diesel and gas engines, and the fact that the drilling companies usually require stock shipments on their equipment, it was necessary to design a unit with which almost any speed engine could be used without expensive changes. In other words, a scheme that would allow the manufacturer of electrical equipment to build and stock drilling equipment, and allow the engine manufacturer to hook up to it readily, irrespective of the speed of the engines. The necessity of equipment of this kind led to the development of the arrangement shown in Fig. 10.



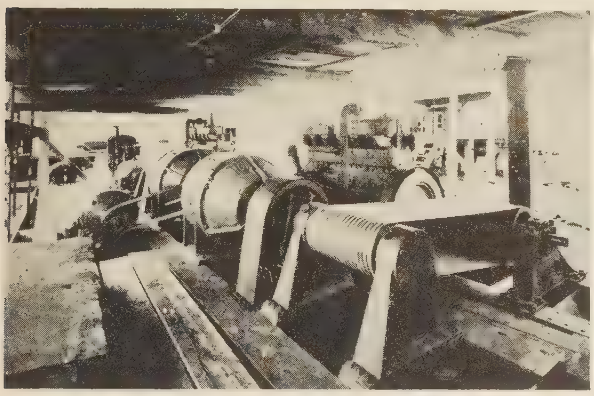


Fig. 11 Equipment Installed According to the Arrangement Shown in Fig. 10

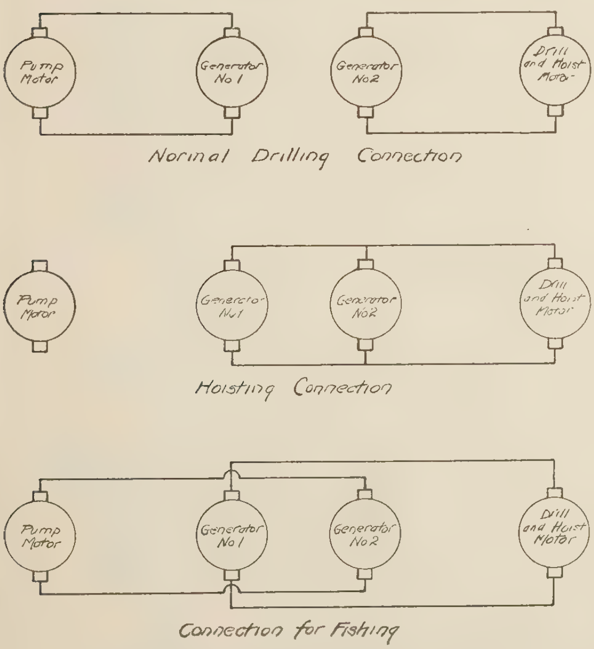


Fig. 12 Electrical Connections Used With Arrangement Shown in Figs. 10 and 11

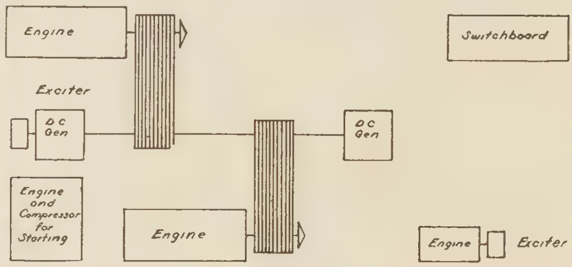


Fig. 13 Modification of Arrangement Shown in Fig. 10

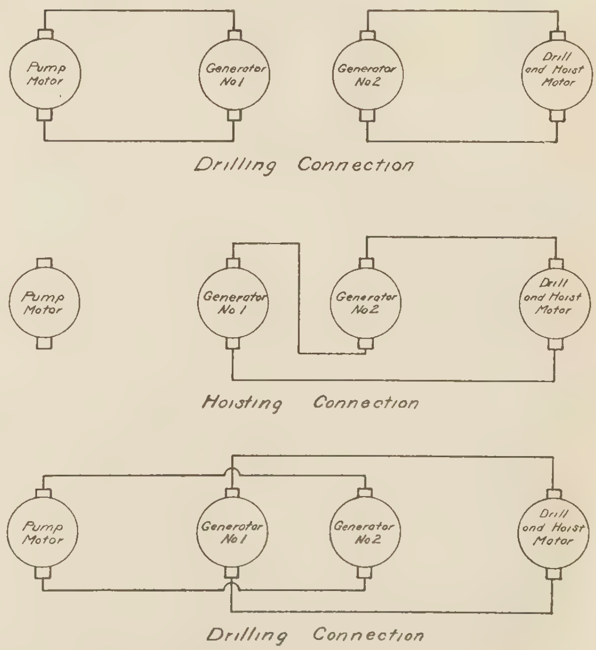


Fig. 14 Series Connections Used With Equipment Shown in Fig. 13

Note that two generators of different ratings are rigidly connected together and mounted on a common base and that the engines are connected to the generator shafts by means of V-belts. Any changes necessary to adapt engines of different speeds can be made by changing the pulley or sheave sizes. Provision is made

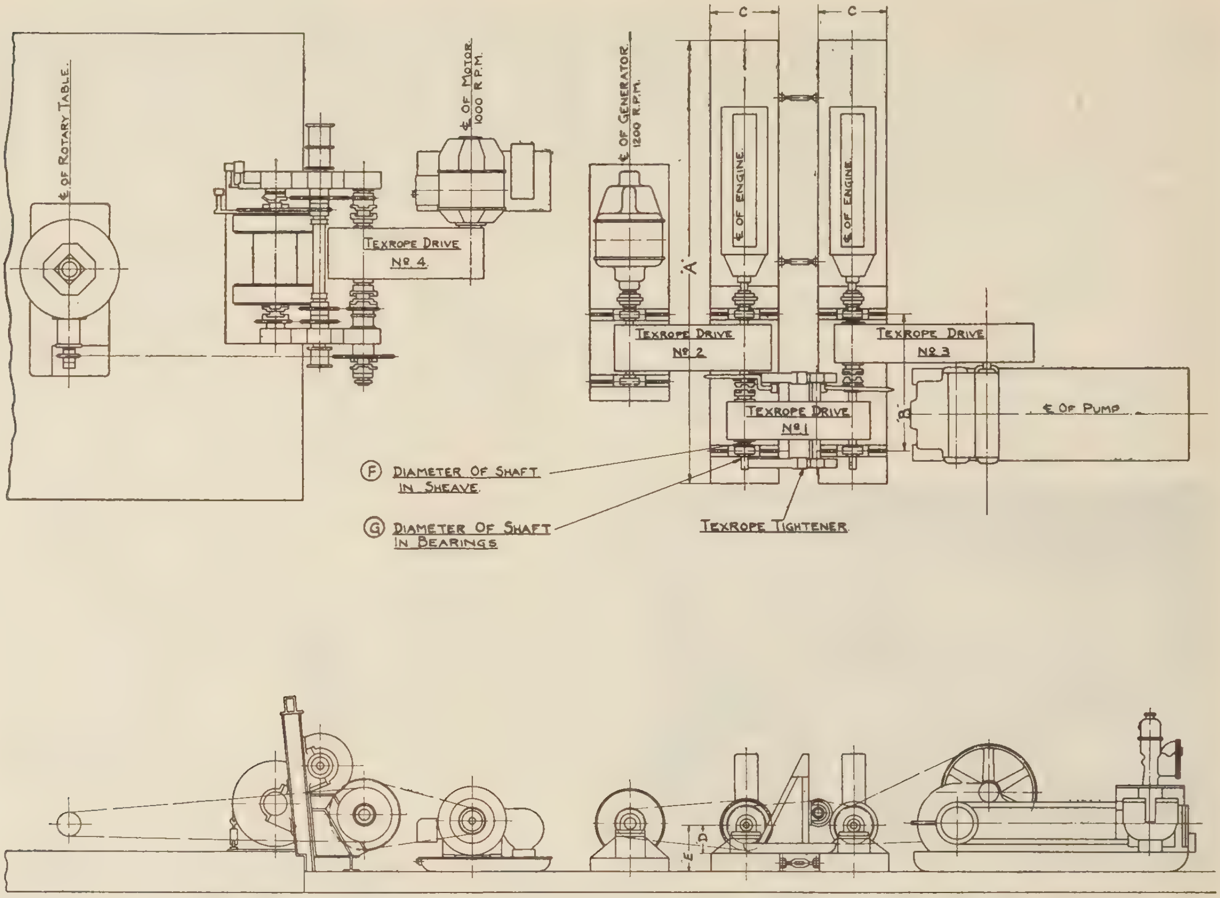


Fig. 15 Electrically Driven System Which Is Mechanically Similar to the System Shown in Fig. 2

by means of friction clutches to use either one or two engines. On original equipment of this type the parallel system of connection was used and still is in use by the manufacturer. The same manufacturer that built the equipment shown in Fig. 8, which uses the series system, built the equipment shown in Fig. 10 which uses the parallel system. The explanation of this is based on one of the fundamental laws of direct-current design, that is, the ease in which generators can be operated in series when connected to individual engines with irregular engine speed and the difficulty experienced in operating generators in parallel, when connected to individual engines where the speed is liable to fluctuate. In the scheme shown in Fig. 10, the generators are rigidly connected together by means of a solid coupling and the parallel system of connection is used because it is impossible for the generator speeds to get out of step. Slight irregularity in firing order or angular variation that might be present in the two engines is taken up in the elasticity of the V-belt drives. Fig. 11 shows a typical installation of the arrangement shown in Fig. 10. The connections for this system are shown in Fig. 12. Where it will be noted that the Ward-Leonard system is again used with an individual generator for each operation, and with the two generators in parallel for hoisting. In most of the systems built to date the control systems have been built almost entirely automatic in the respect that the setup or change in connections is accomplished by means of a small master drum at the driller's position. With this arrangement practically no hand switching is necessary.

A modification of the layout shown in Fig. 10 is shown in Fig. 13, the differences being in the mechanical arrangement of the

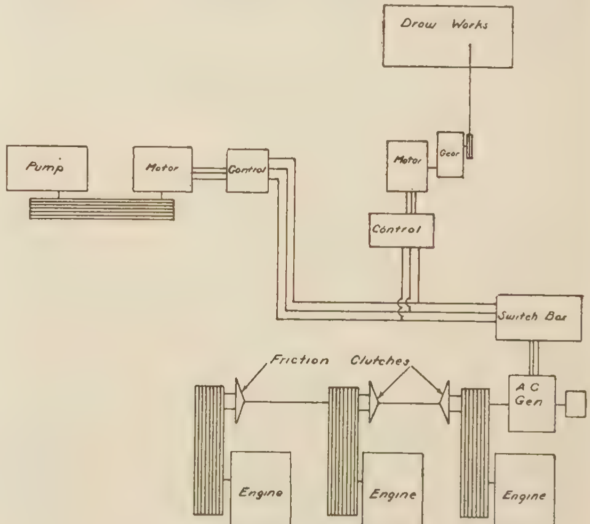


Fig. 16 Arrangement of Internal-Combustion Engines for Driving Alternating-Current Drilling Equipment

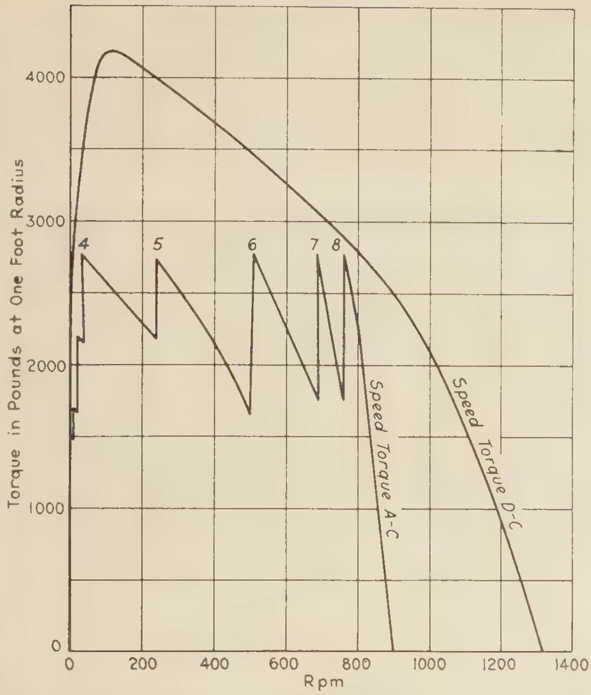


FIG. 17 TORQUE AVAILABLE WITH SAME GEAR RATIO AND SAME MAXIMUM ENGINE HORSEPOWER IN ALTERNATING- AND DIRECT-CURRENT EQUIPMENT

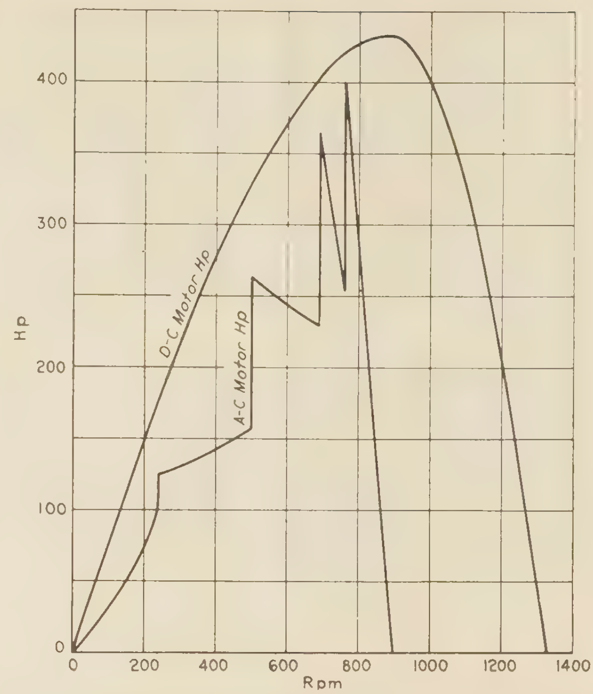


FIG. 18 USEFUL MOTOR HORSEPOWER WITH SAME MAXIMUM ENGINE HORSEPOWER IN ALTERNATING- AND DIRECT-CURRENT EQUIPMENT

engines and drives and the fact that provision is made for running the generators separately by the disengaging of an easily detachable coupling. Because of the fact that the engines can be and are run separately, the series system of electrical connection is used as shown in Fig. 14. Fig. 14 shows that for normal drilling operations separate generators are provided for both pump and drilling motors, while for heavy-duty hoisting two generators are run in series. This could be done either with the coupling engaged or disengaged. Because of the large differences in the power requirements between the table rotation and the mud pump, it is possible to use generators with a wide difference in ratings. In the hookup shown in Fig. 12, the ratings of the generators are additive, or in other words the full capacity of both generators is available for hoisting. With the hookup shown in Fig. 14, it is necessary to use generators of almost identical rating because they are run in series, and if different ratings are used for the two generators then the hoisting power available is limited to twice the rating of the small generator.

The facts that the initial cost of complete electric rigs is rather high, and that the driller is more familiar with mechanical rigs than with electrical rigs, because of the larger number of mechanical rigs in service, led to the development of the arrangement shown in Fig. 15. This arrangement is almost identical with that shown in Fig. 2 with the exception that a generator is used instead of the reverse clutch, and the conventional draw-works motor drive is used. This arrangement gives the high-torque, low-speed characteristics of the direct-current system for hoisting, allows a wide range of table speeds, and at the same time allows the pump to be operated at its best operating point. In this scheme the generator and exciter are designed for a wide speed variation in some cases as high as 50 per cent. The engines are normally operated with compounding drives in service, which means they are not only compounded during the hoisting operation but also for normal

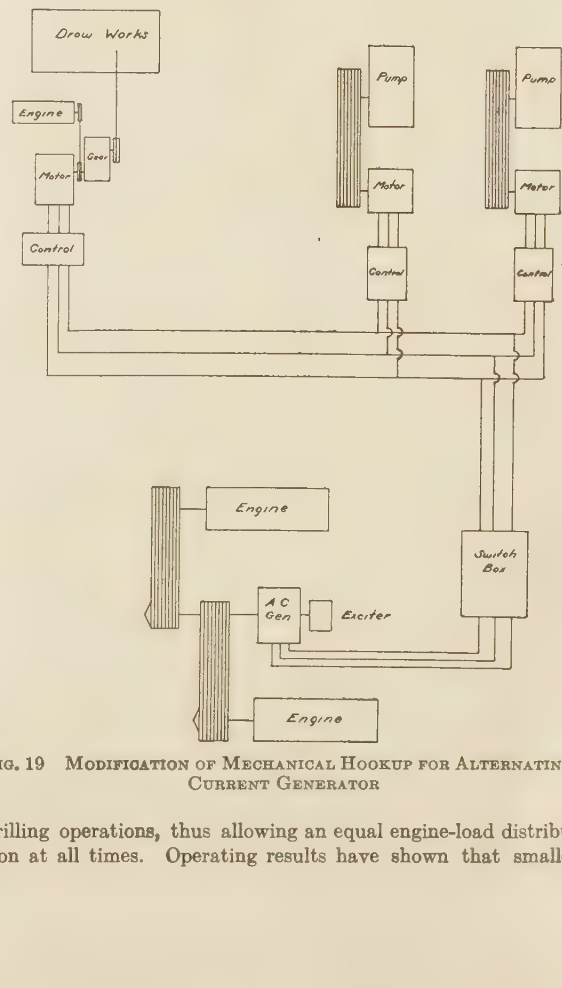


FIG. 19 MODIFICATION OF MECHANICAL HOOKUP FOR ALTERNATING-CURRENT GENERATOR

drilling operations, thus allowing an equal engine-load distribution at all times. Operating results have shown that smaller

engines can be used with this design than for any of the straight mechanical rigs for the same duty.

The fact that a large number of alternating-current rigs in the Seminole and Oklahoma City fields were operated on purchased power and were subsequently stacked, led to some thought being given to alternating-current generator plants driven by internal-combustion engines, thus allowing these rigs to be salvaged and put back in service. Several different designs have been made to accomplish this purpose. One such design is shown in Fig. 16. This design includes three slow-speed, twin-cylinder oil engines all belted to a common line shaft which in turn is direct-connected to an alternating-current generator. From that point on conventional electrical connections were used.

Because of the inherent torque characteristics of the alternating-current motor and also the fact that it is impossible to differentially wind alternating-current generators and provide nonstalling features for the engine, it has been necessary to provide greater engine horsepower than with the direct-current units to accomplish the same results. This is shown graphically in Fig. 17, which shows the torque available with both types of equipment, and in Fig. 18 which shows the useful horsepower available for both types. In Fig. 19 is depicted a modification of the mechanical hookup for alternating-current generators.

In all the alternating-current designs it will be noted that one generator is used with one or more engines to drive it. An attempt was made several years ago to use the conventional method of paralleling alternating-current generators electrically. Because of the instability of the ordinary governors for internal-combustion engines, it was not possible to keep the generators in parallel with any degree of satisfaction.

The authors have attempted to show, without thought being given to the advantages and disadvantages of the different arrangements described, the several methods of mechanical or electrical transmission now in common use for the utilization of the power of the internal-combustion engine in rotary drilling operations. Like all other industries, it would be almost safe to say that the initial cost of the equipment is represented in some advantages or disadvantages. For instance a straight mechanical rig is the cheapest but the first cost introduces some very decided limitations. The half-electrical and half-mechanical rig has eliminated some of the limitations of the straight mechanical rig but is more costly, while the full direct-current electrical rig is the costliest; but it equals if not excels the results from the steam rotary drilling rig with great savings in fuel and water.

The Collection and Evaluation of Data for the Design of Steam-Generating Units

By B. J. CROSS,[1] NEW YORK, N. Y.

The author points out that rational progress in the development of steam-generating units can be made by careful deductions from known facts about such units, and by extrapolation of actual operating data. The purpose of the paper is to relate some of the difficulties encountered, and the care necessary, in making field measurements in obtaining such operating data.

THE PERFORMANCE of a steam-generating unit is "built" into it by the design. Its performance is fixed by the arrangement of heating surfaces and the path of gases over these surfaces. If the surface could be maintained clean and the gas flow uniformly distributed over it, its performance could be accurately predicted. Uncertainties of performance are the result of fouling of the surfaces and unequal distribution of gases.

Rational progress in the development of steam-generating units must be made step by step, the operating experience of one design leading to the development of the next. It is obvious, however, that if there is to be progress, ventures must be made into new territory. The hazards of failure of such ventures can be greatly reduced by careful deduction from known facts and extrapolation of actual operating data. The purpose of this paper is to indicate some of the difficulties encountered and the care necessary in making field measurements in obtaining such operating data. For the determination of overall performance of a steam-gênerating unit, only end-point data are necessary. Heat input, heat output, and heat lossses only need be considered. For the purpose of obtaining design data, measurements throughout the unit are required and the performance of each part of the unit must be carefully studied.

The rate of heat transfer from a hot fluid to cooler absorbing surfaces may be calculated with a satisfactory degree of accuracy when the mass and temperature of the fluid are known, when the flow of fluid is uniformly distributed over the heating surfaces, and when the heating surfaces are clean. These ideal conditions never occur in practice, and the designer of heat-absorbing equipment must consider both theoretical and practical data; in general, the shape or slope of an absorption curve may be determined from a theoretical consideration, but empirical constants must be established to locate the curve with respect to its reference axes.

The problem of design of a steam-generating unit begins with the furnace. It is there that the heat latent in the fuel must be developed for delivery to the boiler. In the not far distant past, the sole function of the furnace was considered to be the evolution of heat and any absorption of heat that occurred was merely incidental to the exposure of boiler tubes to the furnace. Water-cooled surface was first introduced into the furnace to protect refractories from erosion by molten ash. It next replaced refractory surface and in the high-capacity furnace of today, refractory surfaces are almost completely eliminated and the absorption of heat has become an important function. In units of recent design 40 to 50 per cent of the available heat in the fuel is absorbed in the furnace.

From a consideration of combustion only, the rating or duty of a furnace is expressed by the heat liberated per cubic foot of combustion space and the effectiveness of the furnace is measured by the composition of gases delivered to the boiler. Considered as a heat-absorbing unit, the rating of a furnace is the heat liberated per square foot of radiant-heat-absorbing surface, and the measure of its performance is the temperature as well as the composition of the gases leaving the furnace.

The area of radiant-heat-absorbing surface may be calculated in various ways. It may be based on the entire circumference of furnace tubes, on one half the circumference, on projected surface of the tubes only, or on the projected surface of tubes and appurtenances such as fins, pegs, or attached blocks. As long as absorption rates are determined on the same basis, it does not matter how the radiant heating surface is computed. Projected areas are recommended for simplicity of calculation. A large part of the discrepancy in published values for furnace absorption rates is due to differences in methods of computing radiant heating surface. Convection-heat-absorbing surface is fixed by official definition. Radiant-heat-absorbing surface should also be officially defined.

The transfer of heat in the furnace is principally by radiation and takes place according to the Stephan-Boltzmann law, involving the difference in the fourth power of the absolute temperatures of the radiating surfaces. As applied to heat absorption in a furnace, the equation of this law may be written

$$Q = C_1A_1T_1^4 - C_2A_2T_2^4$$

where Q is the quantity of heat absorbed, C is the radiation constant including the emissivity factor, A is the surface area, and T is the absolute surface temperature. The subscripts 1 and 2 refer respectively to the hotter and the cooler surfaces. This expression treats each surface separately as radiating surface and assumes the difference in heat radiated to be the net heat transferred.

The factor C_1 can be based on an emissivity factor of unity without serious error. The area A_1 will vary with the method of firing and also with the rate of firing and percentage of excess air. If we consider the outer envelop of the flame as the active radiat-

[1] Assistant Engineer, Development and Research, Combustion Engineering Company, Inc. Mem. A.S.M.E. Mr. Cross was graduated from Colorado College in 1913 with an A.B. degree. He was then employed by the Blue Bird Gold Mining Company, Cripple Creek, Colo., in drafting, surveying, and sampling. In 1914 and 1915 he served with the T. M. Park Mining Company, Tucson, Ariz. He taught physics and chemistry in the high school at Glenwood Springs, Colo., from 1915 to 1917. From 1918 to 1920 he served with the U. S. Bureau of Mines at Pittsburgh, Pa., and Seattle, Wash. From 1920 to 1931 he was engaged in research and testing for the Combustion Engineering Company, Inc., New York, N. Y. He entered the employ of FosterWheeler Company in 1931 as research and design engineer, and resigned in 1934 to assume his present position.

Contributed jointly by the Heat Transfer Committee of the Process Industries Division and the Power Division and presented at the Annual Meeting of The American Society of Mechanical Engineers, held in New York, N. Y., November 30 to December 4, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until April 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

ing surface, the area A_1 will always be smaller than A_2 which is its limiting value. The temperature T_1 does not exist as such. It is the average temperature corresponding to the average rate of absorption. The factor C_2 for the wall surface depends upon the type of wall construction and upon its state of cleanliness. The area A_2 is fixed by the design. The temperature T_2 of the

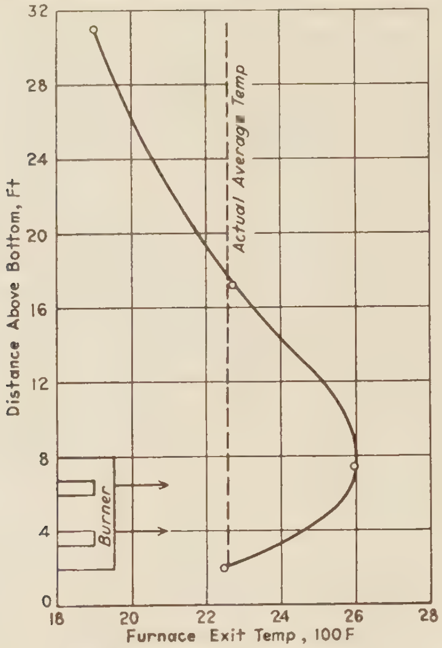


Fig. 1 Furnace-Temperature Gradient for a Completely Water-Cooled Furnace Fired With Powdered Coal

wall surface is controlled in some measure by the design pressure but is greatly affected by the state of cleanliness. For a clean tube surface the temperature T_2 cannot greatly exceed the temperature corresponding to the operating steam pressure, but if covered with ash it can assume any temperature up to the fluid temperature of the slag. When boilers are operated at constant high ratings, wall tubes may become encased with a thin layer of almost vitreous slag which must be close to the molten temperature on the outer surfaces. When the rating is lowered, these accumulations fall off. When the boiler is operated with variable rating, slag is constantly building up and falling off so that furnace surfaces remain comparatively clean.

A furnace-temperature gradient is shown in Fig. 1 for a completely water-cooled furnace fired with powdered coal. The burners are arranged tangentially at the bottom of the furnace. The temperatures shown were measured with thermocouples of platinum platinum rhodium inserted through openings at different levels in the furnace. They are average readings over an insertion distance of about 8 ft. At the lower part of the furnace they may be correct within 100 F. The theoretical flame temperature was 3600 F, while the maximum measured temperature was 2600 F. The theoretical temperature of flame cannot be attained unless the combustion of the fuel is instantaneous. Actually, a definite time is required for combustion, and radiation occurs during combustion so that the theoretical temperature is never reached.

The only furnace temperature that can be measured with any degree of accuracy is the temperature of gases leaving the furnace, and most of the methods that have been proposed for computing furnace absorption rates are based on the Stephan-Boltzmann law using the furnace-outlet temperatures.

Firing rates and absorption rates are plotted in Figs. 2 and 3 against furnace-outlet temperatures. Fig. 2 shows curves for a completely water-cooled furnace, tangentially fired with pulverized coal. This is the unit, the furnace temperature of which is shown in Fig. 1. Fig. 3 shows a curve for a vertically fired unit also completely water cooled. For the purpose of comparison,

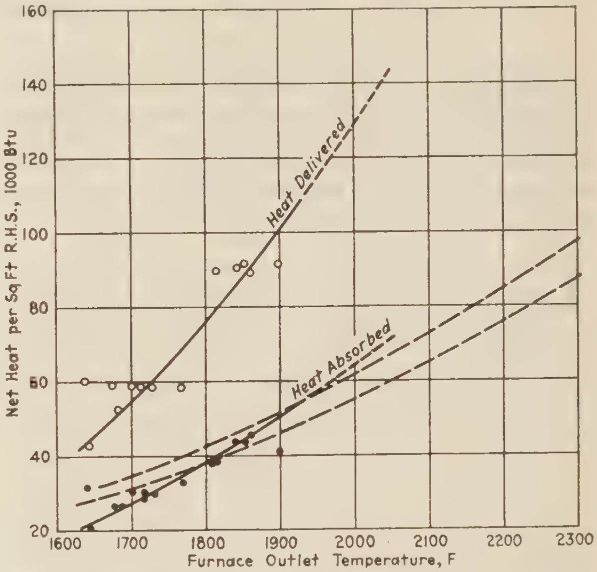


Fig. 2 Firing and Absorption Rates in a Water-Cooled Furnace Fired With Powdered Coal

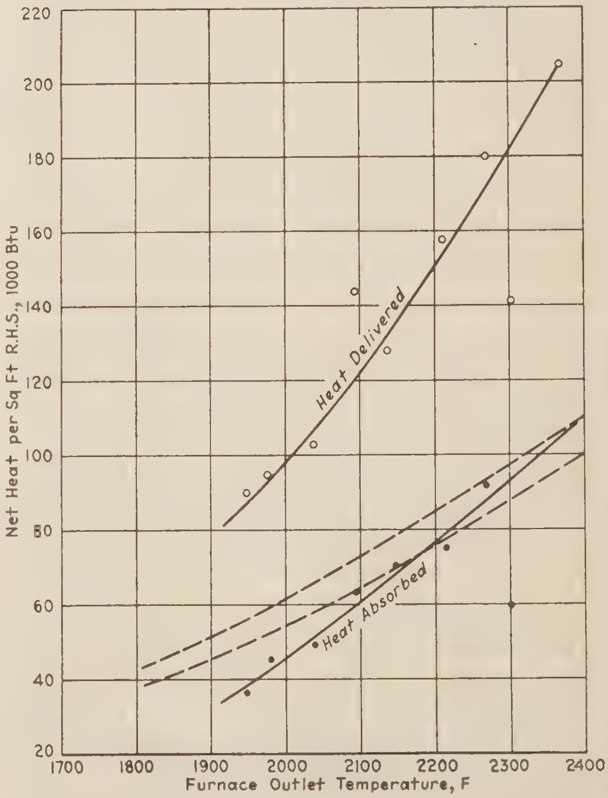


Fig. 3 Firing and Absorption Rates in a Water-Cooled Vertically Fired Furnace

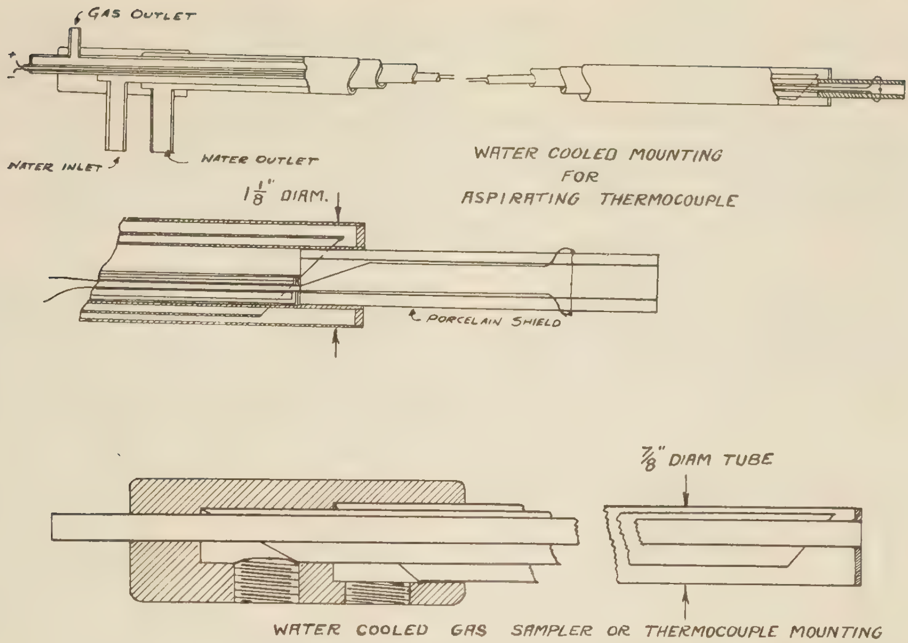


Fig. 4 Plain and Velocity Thermocouples in Water-Cooled Mountings

the Stephan-Boltzmann curve, based on furnace-outlet temperatures, is shown in each figure. The heat rates shown on the ordinates is the net heat per square foot of radiant heating surface. This net heat is equal to the gross heating value of the fuel plus the heat in the preheated air less the latent heat of water vapor and the heat in unburned carbon. It will be noted in both of these figures that the actual absorption rate has a steeper slope than the Stephan-Boltzmann curve. This may be accounted for by the increasing value of A_1 with higher combustion rates and also by an increase in the convection component with the increased velocity of gases in the furnace. These figures indicate the difficulties in applying the Stephan-Boltzmann law to the solution of problems in furnace heat transmission. That these difficulties may not be insurmountable is indicated by some of the recent treatises on the subject.

The measurement of the temperature of a stream of gases adjacent to or surrounded by cooler surfaces is liable to a "radiation error." Theoretically, with any instrument having a mass exposed to the gases, the true temperature will never be indicated. The instrument is receiving heat by conduction and radiation from the gases and is losing heat by radiation to the cooler surfaces. It will finally assume an equilibrium temperature somewhat different from that of the gases. The smaller the mass of the instrument, the closer will be the equilibrium temperature to the true gas temperature. Because of the small mass possible, the thermocouple is well adapted to the measurement of gas temperatures. For the furnace-outlet temperature thermocouples of platinum platinum alloy are necessary, preferably in water-cooled mountings. With such couples, wire diameters as low as 0.005 in. may be used. The use of small wire reduces the radiation error and also the error due to conduction of heat along the wire to the water-cooled mounting.

One difficulty that is experienced with thermocouples is that due to slag building up on the wire and increasing the effective diameter, a false reading results because of the shielding effect and increased radiation. The couple must be frequently removed and cleaned. Couples of the velocity type are sometimes used. Such couples have a refractory shield surrounding the hot junction to reduce the radiation and are also arranged so that gas may be drawn over the junction at relatively high velocity. Such couples give good temperature readings while they remain clean but they foul rapidly and require frequent cleaning. This is particularly true in powdered-coal furnaces.

Since a thermocouple located at the furnace outlet is exposed to radiation from the hotter furnace below it as well as to the cooler surfaces above, it is questionable whether the radiation error will be plus or minus. In several cases where the temperature was measured with two couples of 0.025 and 0.012 in. diameter, the larger couple gave the higher reading although the differences were not great. After experience with both shielded and bare couples, the author's preference is the bare couple. It is much easier to clean and does not require cleaning as often as the velocity couple.

Fig. 4 shows plain and velocity couples in water-cooled mountings. For maximum water area and minimum exposed surface, such mountings should be made up with thin-wall brass tubing. Lengths up to 12 ft can be handled without difficulty.

As the gas-temperature measurements at the furnace outlet are at the largest flow section of the unit, a large number of points must be taken to get an average, and considerable time is required for a traverse. Fortunately, while most large steam-generating units can be operated under quite steady conditions for periods of time long enough to make complete measurements over the entire unit, care should be taken that a change of operating conditions does not occur while the traverses are being made.

Ordinarily, the arithmetical average of the individual points of a temperature traverse of the furnace outlet may be considered to be a true average temperature. If there are wide differences in individual readings, differences in gas velocity may be suspected. If, however, the temperature be reasonably constant over the section, differences in gas velocity need not be considered.

The heat transfer for all surfaces above the furnace is chiefly by convection, radiation transfer becoming less and less a factor as the temperature of the gas is reduced. The factors controlling the convection-transfer rate have been the subject of much study and theoretical values can be calculated that have good agree-

ment with practical values. Heat transfer by convection is represented by the equation

$$Q = RS(tm)$$

where R is the convection-transfer rate, Btu per sq ft hr deg F; S is the surface, sq ft, and tm is the mean temperature difference between the gases and the surface. The heat transferred by convection also must equal the product of the weight, the specific heat and the temperature drop of the gases or

$$Q = Wc_p(t_1 - t_2) \text{ and } R = \frac{Wc_p(t_1 - t_2)}{S(tm)}$$

For the experimental determination of R, the temperature and weight of gas is required. An inspection of the last equation

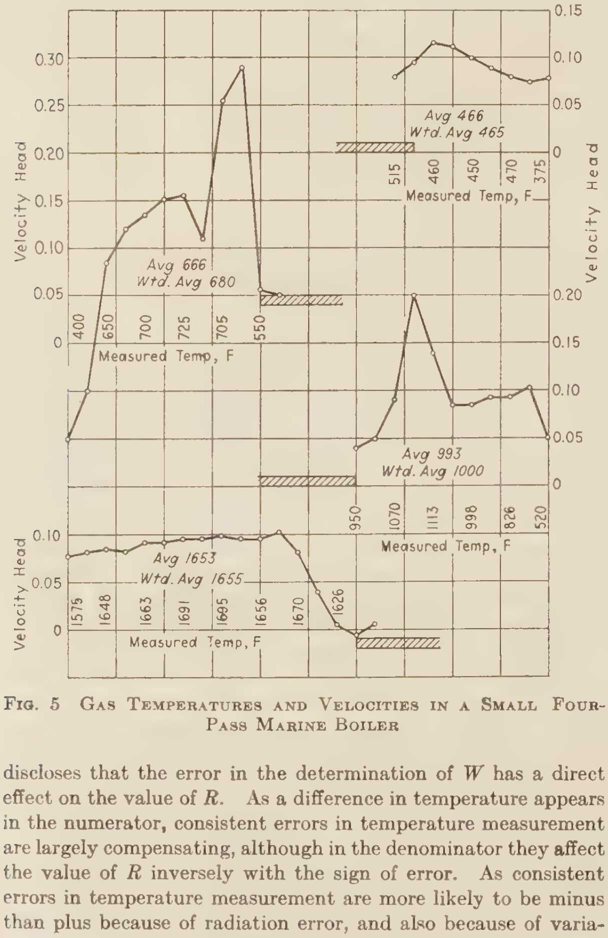


Fig. 5 Gas Temperatures and Velocities in a Small Four-Pass Marine Boiler

discloses that the error in the determination of W has a direct effect on the value of R. As a difference in temperature appears in the numerator, consistent errors in temperature measurement are largely compensating, although in the denominator they affect the value of R inversely with the sign of error. As consistent errors in temperature measurement are more likely to be minus than plus because of radiation error, and also because of variation in gas velocity, the determined values for R are likely to be high.

Unlike measurements at the furnace outlet, the radiation error in gas-temperature measurements in the boiler passes must always be negative, because the instrument used is completely surrounded by surfaces at a lower temperature than that of the gases. The radiation error is less at high boiler ratings when the gas velocity is high. Shielded velocity thermocouples or thermocouples made with small wire and small hot junctions should be used. The small-wire bare thermocouple is recommended for its simplicity. At the ratings at which present-day units are usually operated, the radiation error should not be large.

The effect of varying velocity when the arithmetical average of a number of readings is taken is to cause a minus error in the temperature. The transfer rate R varies with a power of the mass flow. If this exponent were unity, the transfer rate would increase at the same rate as the flow and the temperature of gas leaving a boiler would remain constant regardless of rating. Actually, the exponent is somewhat less than unity and the gas temperature increases with flow. The points of high velocity therefore become points of high temperature, and if given equal weight as in an arithmetical average, the average gas temperature would be in error on the low side.

Bulletin 214 of the U. S. Bureau of Mines describes tests on a small marine boiler during which tests special investigations of gas temperature and gas velocity were made. The results of one test on a four-pass boiler are shown graphically in Fig. 5 for each of the four passes. The arithmetical mean temperature is compared with a weighted mean based on velocity and density. It will be seen that in the first pass, where there is no relation between velocity and temperature, there is practically no difference between the arithmetical and weighted means. In the second and third passes, after the gases have passed over the heating surface, the high-velocity points become high-temperature points and the weighted average gives a higher value than the arithmetical average. The difference in the two averages is, however, surprisingly small considering the range in velocities. In the fourth pass there is less variation in velocity and temperature and the arithmetical and weighted mean temperatures are practically the same.

In most instances the arithmetical average of a number of readings taken over a section of gas flow will be sufficiently accurate. When a high degree of accuracy is required or when great differences in velocity occur, velocity-head and temperature readings should be taken simultaneously and the weighted average obtained. The design of a combination thermocouple and pitot tube is not difficult, particularly as only relative and not absolute velocities are required.

The weight of gas resulting from the combustion of fuel may be determined by means of a carbon balance. The weight of dry gas per pound of fuel is given by the familiar formula

$$W \text{ (dry)} = \frac{4CO_2 + O_2 + 700}{3(CO_2 + CO)} C_b$$

where the various gases are in per cent by volume and C_b is the pounds of carbon burned per pound of fuel. To obtain the total weight of gas per pound of fuel there must be added to the dry gas the moisture in the fuel, the water vapor formed from burning hydrogen, and the water vapor in the air used for combustion.

To obtain a representative value for the composition of gas at a flow section of the boiler, samples must be at a number of points corresponding to the points of temperature measurement.

Except for the fact that air infiltration occurs throughout the unit, only one determination of gas flow would need to be made for studies of the entire unit. Air infiltration increases with draft and is, therefore, likely to be higher in the latter stages of heat absorption; that is, in the economizer and air heater. For a complete study of the steam-generating unit, four gas-sample traverses are necessary: One at the furnace outlet in connection with studies of the furnace, superheater, and boiler surface below the superheater; one at the boiler outlet; one at the economizer outlet; and one at the air-heater outlet. For each of these sections of heating surface beyond the first pass, the average of the inlet- and outlet-gas weights should be used. As in making temperature averages, differences in gas velocity must be considered in making up the average of the analysis of gas samples, and if great differences in gas velocity are found to exist, weighted averages should be used.

The rate of heat transfer in that portion of boiler surface below the superheater is of interest chiefly in the superheater design. The temperature of the gases leaving the furnace must be reduced to accord with the degree of superheat required and also to comply with the limit set by the temperature tolerance of the metal of the superheater elements. With the present-day demand for higher superheat temperature, and with the development and use of high-temperature alloys, the amount of surface below the superheater is becoming smaller and wider tube spacing is being used. This smaller surface with wider tube spacing presents new factors in the mathematical determination of heat-transfer rates which are perhaps not covered in existing formulas, and new experimental data are required.

The superheater may be either of the convection or radiant type or a combination of both types. Radiant superheaters are located in the furnace and may be treated in a similar way to water-cooled surface. Convection superheaters are located in the path of gases after a part or all of the boiler surface. The calculation of the heat-transfer rate for a superheater is more involved than for water-evaporating surfaces, largely because the mean temperature difference is difficult to determine. The multiloop design of large superheaters does not permit either a true counterflow or true parallel-flow arrangement. For this reason, superheater transfer formulas are almost entirely based on empirical data.

Economizers, while designed on a counterflow principle are not, strictly speaking, true counterflow, but similar to the superheater are partially crossflow. However, because of the comparatively high heat capacity of water, there is only a small water-temperature rise over the length of a single tube and for practical purposes, economizers of the usual design may be considered truly counterflow.

Gas temperatures and gas weights for the economizer may be determined as heretofore described without much difficulty. The sections of gas flow are smaller than for boiler passes and the traverses are correspondingly simplified. The heat absorbed by an economizer may be determined both by the gas-temperature drop and by the water-temperature rise, one method serving as a check upon the other. The latter method probably is the more accurate as water temperatures may be measured more accurately than gas temperatures.

The transfer of heat in the economizer more than for any other part of a steam-generating unit, lends itself to mathematical analysis. When the economizer elements have extended surfaces, the effectiveness of such additional surfaces must be determined experimentally. A factor may then be applied to the total surface to reduce it to effective tube surface.

Air heaters are of three general types: The plate or envelope type, the tubular type, and the regenerative type. The plate and tubular heaters are similar in principle differing chiefly in the method of confining and separating the air and gas. In the regenerative air heater, the heat of the gas is first imparted to a solid. This solid is then transferred mechanically to the air stream and the heat is given up to the air. The principle of heat transfer is not greatly different from the other types of heater, but the temperature gradients are somewhat involved and difficult to define. An exact mathematical analysis and derivation of air-heater transfer rates is impractical and design formulas are based largely on empirical data.

Air heaters are always designed on the counterflow principle, but because of entrance and exit requirements, a part of the path is crossflow. The longer the heater can be made, the more nearly it approaches true counterflow. In all air heaters, the transfer of heat involves two gaseous mediums and the overall transfer rate from the gas to the air is a combination rate based on the transfer rate of the gas to a solid and from the solid to air. If R_g is the gas transfer rate and R_a is the air transfer rate, the net rate of transfer R from the gas to the air is expressed by

$$\frac{1}{R} = \frac{1}{R_g} + \frac{1}{R_a}$$

While this principle holds true for all transfer rates throughout the boiler, the transfer rate on the water sides of tubes is so high and the value of its reciprocal is so low that it may be neglected.

The heat absorbed by an air heater is determined by the weight and temperature drop of gas passed through it. If the weight of air passing through the heater could be accurately determined, it would serve as an independent check on the heat absorbed. Because of air infiltration ahead of the air heater, the weight of air passing through the heater is always less than the

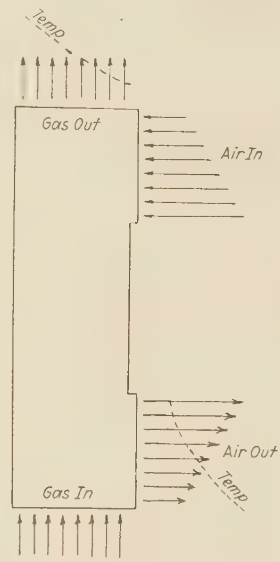


Fig. 6 Diagram of Air Heater Illustrating Unfavorable Flow Conditions

amount indicated by the analysis of gases passing through the heater.

The temperature of gases to and from the heater and the temperature of air from the heater may be determined by temperature traverses at sections of flow. Because the encasing walls of ducts and flues absorb but little heat, their temperature is not greatly below that of the gases and there will be no appreciable error due to radiation. However, differences in velocity must be considered. Points of high gas velocity become high-temperature points as has been previously described. However, points of high or low gas temperature occur independently of gas velocity because of differences in air velocity. On the air side of the heater, high-velocity points become low-temperature points and high- and low-temperature points may also occur independently of air velocity, being caused by differences in gas velocity. Ordinarily, air heaters are designed in such a way that large differences in velocity of either gas or air cannot occur, but sometimes the design is affected by mechanical interferences and space limitations and unfavorable conditions for gas and air flow may result. An extreme case is illustrated in Fig. 6. The velocity variation is indicated by the length of the arrows, and the variation in temperature is indicated by the curves. In such a case weighted averages would be necessary to obtain representative temperatures.

The design of steam-generating units will probably never ap-

proach anything like an exact science. The behavior of water in its liquid and vapor forms has been thoroughly investigated and accurate tables of its properties have been prepared. Because of its high heat capacity and high density, it is ideal as a carrier of energy. It can be confined to small tubes and its flow directed, if not with accuracy at least with certainty. As an absorber of heat it leaves little to be desired.

On the other hand, fuels are many and varied. They may be solid, liquid, or gaseous. They vary widely in physical properties and chemical composition and contain many impurities. They must be burned with air which contains 80 per cent inert substance. The hot gases derived from their combustion have low heat capacity and low mass. Because of the energy cost in moving so tenuous a medium, velocities are limited and large flow sections must be provided. These gases must be passed in series over each of the several parts of the steam-generating unit. Thus, the performance of each part is affected by the performance of all preceding parts.

Considering the difficulties involved, the actual performance of steam-generating units in general compares favorably with design performance. That occasional departures occur indicates that all factors are not completely under control. Emphasis should be made, not on occasional misses but on the large number of hits.

Determination of the Effect of Certain Installation Conditions on the Coefficients of Sharp-Edged Orifices

By S. R. BEITLER[1] and J. E. OVERBECK,[2] COLUMBUS, OHIO

This paper presents the results of a study made to determine the effects of certain installations on the coefficients of discharge of sharp-edged orifices. The coefficient determinations were made with the orifice plates clamped between flanges made up on the end of pipe so that no appreciable gap existed between the end of the pipe and the orifice plate. Some of the orifice flanges were constructed with a core or recess which left a gap of an inch or more between the end of the pipe and the orifice plate, this being done to simulate meters of this type now used to a greater or less extent. The authors present results obtained from the tests of such orifices set in 2-, 4-, and 8-in. pipes, as well as results from tests of standard-reference orifices. All results are presented graphically.

THE MAJOR part of the research work of the Joint Committee of The American Society of Mechanical Engineers and the American Gas Association on Orifice Coefficients was the determination of the correct coefficients of discharge of sharp-edged orifices. The installation of the orifice has considerable influence on the value of the coefficient, and therefore the committee was forced to make a comprehensive study of the effects that various conditions of installation had on the coefficients of the orifices. The coefficient determinations were made with the orifice plates clamped between flanges made up on the end of pipe so that there was no appreciable gap between the end of the pipe and the orifice plate. The pressure-tap holes were 0.25 in. in diameter.

In some commercial installations, especially for the measurement of natural gas, the orifice flanges were constructed with a "core" or recess which left a gap of an inch or more between the end of the pipe and the orifice plate. This type of flange was used generally only with meters having flange and pipe taps. The diameter of this core, or recess, was usually about the same as the outside diameter of the pipe. Most of these orifice flanges, as well as some of the newer ones without recesses, were constructed with large pressure-tap holes in order to reduce the possibility of the connections being clogged by dirt or ice.

Since the users of meters having this type of flange would be placed at considerable expense to reconstruct all meter flanges that were recessed, and since operating difficulties might ensue with the use of too small pressure taps, the committee felt that an investigation should be made to determine the effect of these types of installations on the coefficients of orifices. These tests were conducted at the South Columbus Metering Station of the Ohio Fuel Gas Company during the fall and winter of 1932–1933.

The method of conducting the tests was to compare two similar orifices in different settings in series, measuring the same gas. Pipes of 2, 4, and 8 in. diameter were used, and comparisons were made using both flange and pipe taps. Two sets of orifices were used for each pipe size. For the 2-in. line there was a total of ten orifices with respective diameters of $^1/_2$, $^3/_4$, 1, $1^1/_4$, and $1^1/_2$ in. The diameters of the orifices for the 4-in. line were $^1/_2$, 1, $1^1/_2$, $2^3/_8$, and 3 in., while those in the 8-in. line were 1, 2, 3, $4^3/_4$, $5^3/_8$, and 6 in. There were 12 orifice plates for the 8-in. line and ten for the 4-in. line.

The orifice plates were made of monel metal $^1/_8$ in. thick punched to the proper outside diameter with the orifice carefully bored to size and the edges scraped to give a sharp square edge. The edges were inspected carefully and were found to be as nearly perfect as was possible with commercial manufacture. The plates were made in the Columbus shops of the Ohio Fuel Gas Company.

Two types of orifice flanges were used for each size line. The one type used at all times for the standard or so-called reference flange, and at times in the second or commercial flange, was made with steel flanges carefully welded to the pipe so that the end of the pipe was flush with the face of the flange and the pipe was smooth and straight inside. This type was called a "steam-type flange." The other type, known as the recessed flange, was made in one of two ways. For the flange-tap tests, used orifice flanges were taken from the stock of the Ohio Fuel Gas Company and screwed onto the end of the pipe in the usual manner. When it was desired to find the effect of different lengths of core, the core was cleaned and an attempt made to use filler rings in the core. It was found that it was very difficult, if not impossible, to fit a ring so that it was smooth inside the pipe wall. Fig. 1 shows the 8-in. cored flange and filler ring.

In some cases different cored flanges were tried with different diameters and lengths of cores. At times different combinations of cored and steam-type flanges were used to determine whether the inlet or outlet core was affecting the coefficient.

For the flange-tap tests, the piping to the flanges was arranged

---

[1] Assistant Professor of Mechanical Engineering, Ohio State University. Mem. A.S.M.E. Mr. Beitler received the degree of bachelor of mechanical engineering at Ohio State in 1920. In 1920–1921 he served as apprentice engineer with the Whiting Corporation of Harvey, Ill. Since 1921 he has been at Ohio State University as assistant and instructor in mechanical engineering. From February, 1927, to date he has been consulting research engineer for the Bailey Meter Company, Cleveland, Ohio.

[2] Gas Measurement Engineer, The Ohio Fuel Gas Company. Mr. Overbeck has been engaged in gas-measurement activities since 1916, with experience in installation, operation, and maintenance of practically every class of gas meter. He has been associated with the research studies made by the Gas Measurement Committee of the American Gas Association and has taken an active part in the research work conducted by the joint A.G.A.-A.S.M.E. Orifice Coefficient Committee.

Contributed by the Joint Committee of The American Society of Mechanical Engineers and the American Gas Association on Orifice Coefficients and presented at the Annual Meeting of The American Society of Mechanical Engineers held in New York, N. Y., November 30 to December 4, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until April 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

as shown in Fig. 2. Although Fig. 2 shows the arrangement of the 4-in. line, the arrangement of the piping for the other two lines was similar. The gas used was supplied through valves from a high-pressure line and was dumped into the intermediate-pressure line supplying the city of Columbus after going through the test setup. Following the regulating valve, the line was straight for about 40 pipe diameters, at the end of which the reference flanges were mounted. They were preceded by

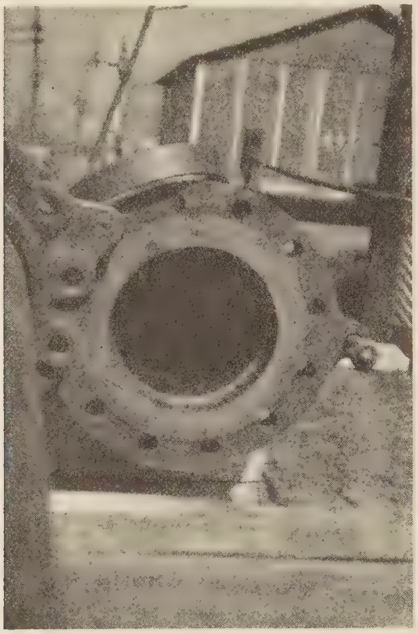


Fig. 1 The 8-In. Recessed Flange and Filler Ring

straightening vanes at six diameters on the inlet of the flange. The line then led to a header, and two lines connected this header to another similar header. These lines were valved so that the gas could be directed through either line. The commercial flanges were mounted in these lines, the steam-type flange in one and the recessed flange in the other. Both flanges were preceded by straightening vanes. The second header was then connected through proper valves to the intermediate-pressure line. This arrangement made it possible to change the orifice in the commercial flange from one type of flange to another without disturbing the orifice in the reference flange.

The general piping layout for the pipe-tap tests is shown in Fig. 3. Although Fig. 3 shows the piping arrangement for the 4-in. line, the arrangements for 2-in. and 8-in. lines were similar to it. The gas was drawn from the same high-pressure line and dumped into the same intermediate-pressure line. The same steam-type flange was used for the reference flange, and the commercial flange was mounted directly below it in the straight pipe. No manifold was used because of the much greater length of pipe required for the pipe taps. Instead of using runs of manifolded pipe for the commercial flanges, the runs were constructed so that they could be interchanged, thus making it possible to put either a steam-type or a recessed-type flange into the line. Fig. 4 shows the measuring station, and the 8-in. line for testing pipe taps.

The static and differential pressures across the orifices were measured by means of manometers mounted as shown in Fig. 5. The static pressure was measured by means of single-leg mercury manometers having a pressure range of about 80 in. Hg. For some of the runs using pipe taps, the pressure in the intermediate-pressure lines was so high and the flow was so great, that the pressure ran higher than could be measured with these manometers and it was necessary to put temporary extensions on the manometers.

The differential pressure was measured by ordinary 50-in. U-type water manometers. The manometers were set up inside a heated building—the one on the extreme left in Fig. 4—and the connections were made to the orifice flanges by means of $^3/_8$-in. pipe and short lengths of $^3/_8$-in. rubber tubing. Care was used in making all pipe joints to eliminate leaks.

Finned-type thermometer wells were placed in the line below each orifice. Mercury-in-glass thermometers were inserted in these to measure the temperature.

The method of taking data was as follows. Two plates with orifices of the same diameter were chosen and placed in the

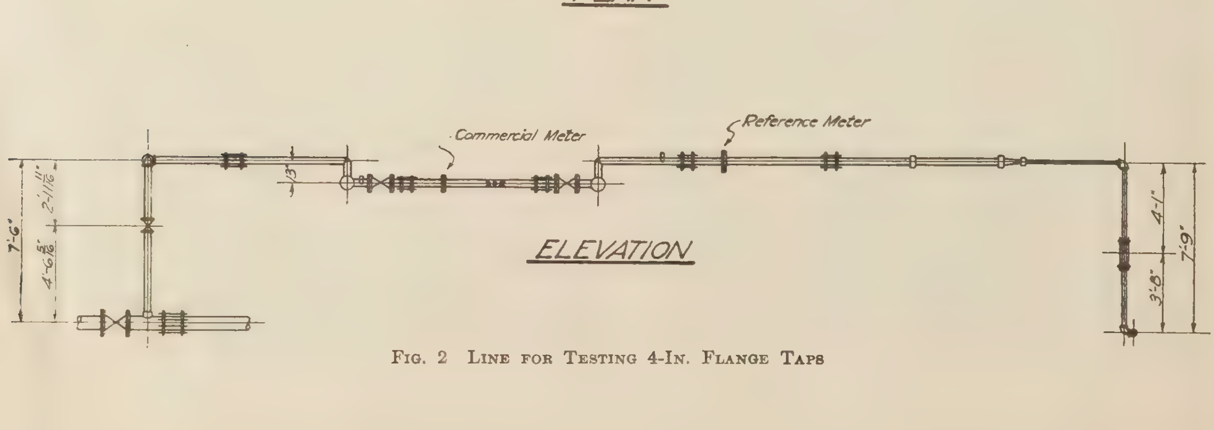


Fig. 2 Line for Testing 4-In. Flange Taps

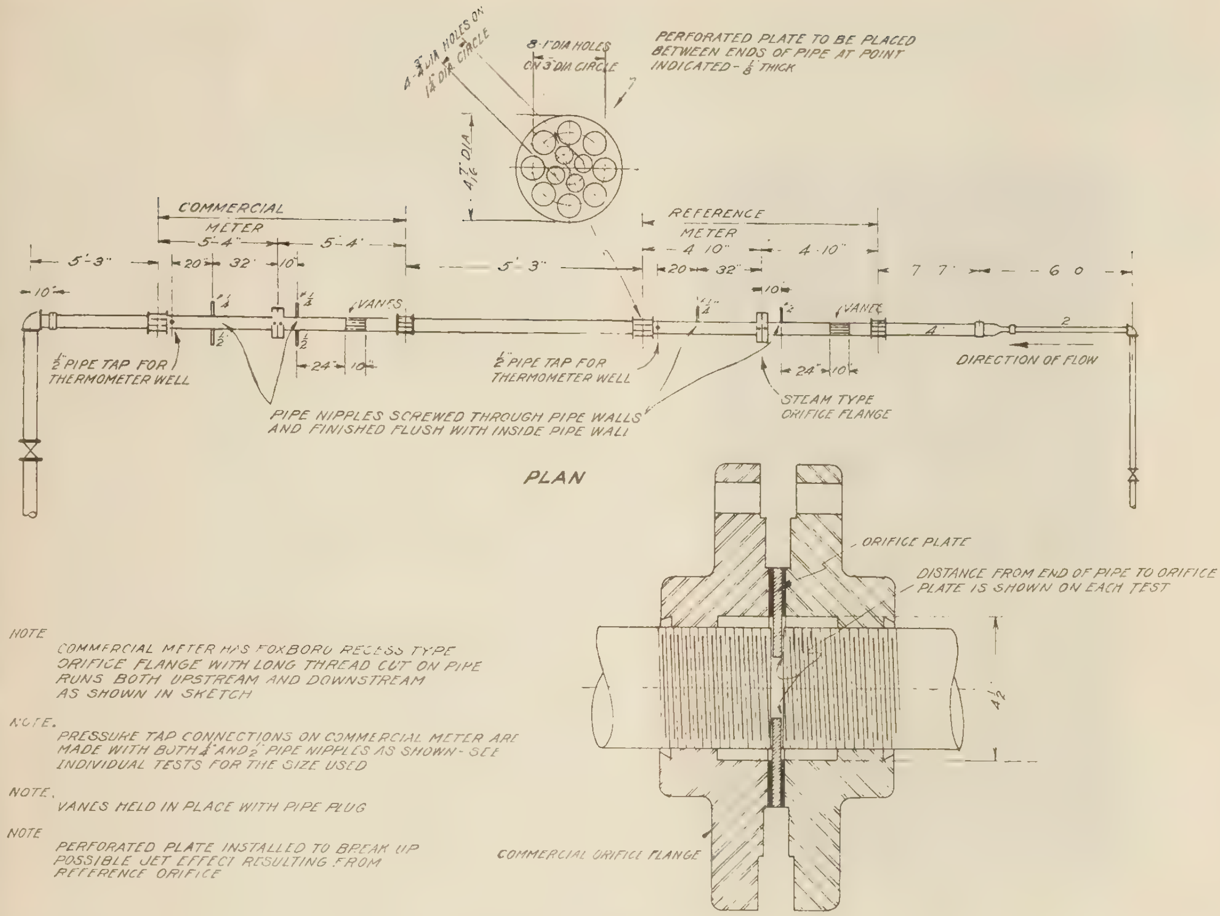


Fig. 3 Line for Testing 4-In. Pipe Taps

steam-type flanges, the one in the reference flange and the other in the commercial flange. The gas was then turned into the line and the flow adjusted until the differential pressure on the reference meter was approximately 10 in. of water. After conditions were steady, three readings were taken of the static and differential pressures and the temperatures for each orifice. The flow was then changed to give a pressure differential of about 25 in. of water and the readings repeated. This was repeated for pressure differentials of 50 in. and 80 in. of water. The plates were then reversed, that is, the plate which had been in the reference flange was placed in the commercial flange and the same series of tests run. The plate in the commercial steam flange was then transferred to the recessed flange and a series of tests run. The plates were again reversed and this series repeated. This general procedure was followed with all of the tests using various types of flanges and various sizes of pressure-tap holes in the commercial flanges.

Results

The results will be given only in graphical form. The general method of analysis was as follows:

The data taken for each test run was first averaged and the calculation was made to determine the ratio

$$r = \frac{K_C}{K_R} = \sqrt{\left(\frac{H_R P_R T_C}{H_C P_C T_R}\right)}$$

where H = differential head, in. water; P = absolute pressure, in. Hg; T = absolute temperature, F; $(\ )_R$ refers to the reference meter; and $(\ )_C$ refers to the commercial meter.

Fig. 4 Measuring Station and Line for Testing 8-In. Pipe Taps

This ratio r gives the value of the coefficient of discharge of the commercial plate divided by the coefficient of the reference plate, and indicates the effect on the coefficient of installation of the orifice. The results of the calculations for any one type of commercial flange were then plotted, the ratio r being plotted against the reference differential head. Since both plates were used in both flanges this gave eight points for each series. A curve was drawn through the average of these points. The use of the reversed plates eliminated any effect of orifice edge

and should have canceled out completely any difference in orifice construction. The effect shown was then the effect of the installation only. These curves for the 2-in. flange taps are shown in Fig. 6.

Next, the point on each curve at a differential pressure of 40 in. of water was plotted against diameter ratio of the orifice for each set of conditions. Fig. 7 shows these curves with the various arrangements of the commercial flange marked on each curve.

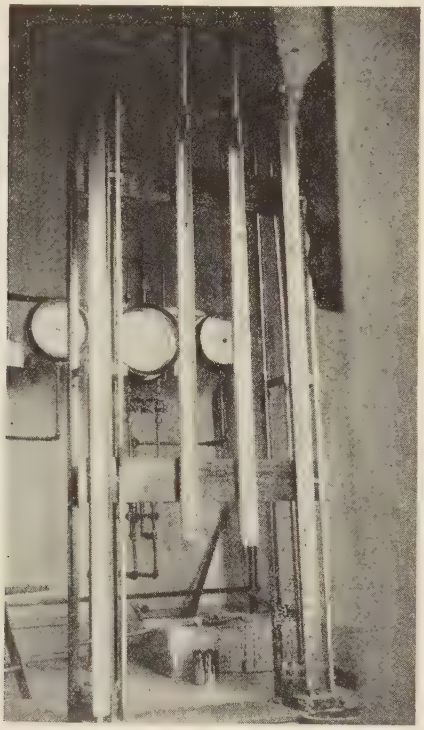


Fig. 5 Manometers Used in the Tests

Fig. 6 Head-Factor Curves for 2-In. Flange Taps

The curve for the steam flange with $^1/_4$-in. pressure taps was then assumed to be the curve without anything affecting the coefficient except uncontrollable items; values of the ratios read from this curve were divided into the ratio values for the other conditions to determine the effect on the coefficient of the various conditions under study. These were plotted and are shown in Fig. 8. The method used in obtaining results for the other lines was approximately the same.

Discussion of Results

The results will be studied for the different line sizes and the different pressure taps separately.

Effect on Flange Taps in a 2-In. Line. Reference to Fig. 8 shows that for these tests the use of $^{23}/_{32}$-in. pressure taps in place of $^1/_4$-in. taps had no effect on the coefficient of the orifice until a diameter ratio of 50 per cent was reached, and that for higher ratios the coefficient of the orifice was decreased slightly, the maximum effect being about 0.5 per cent at a diameter ratio of 75 per cent.

The effect of the recess is rather hard to understand. It will be seen that as the diameter ratio increases the coefficient of the orifice with the recessed flange is increased until there is a difference of about 1.75 per cent at a diameter ratio of 60 per cent, and then this effect decreases until at a diameter ratio of 75 per cent it has fallen to 0.75 per cent. The effect of the recess would undoubtedly be to increase the coefficient of the orifice since it would increase the turbulence directly ahead of the orifice and so decrease the contraction of the steam. Apparently, when the orifice ratio was large this effect was counteracted by some other effect, possibly friction, which decreased the effect of the core on the orifice coefficient. However, if the coefficients determined with steam flanges and $^1/_4$-in. pressure

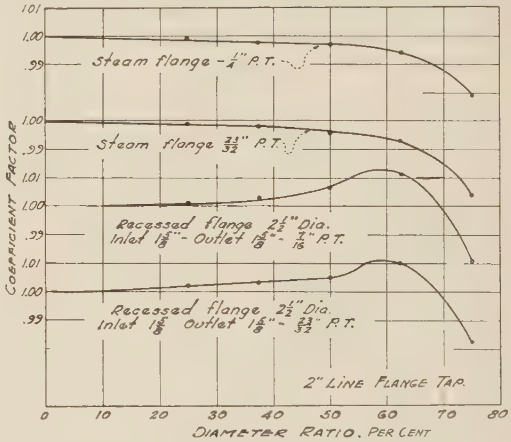


Fig. 7 Diameter-Ratio-Factor Curves for 2-In. Flange Taps

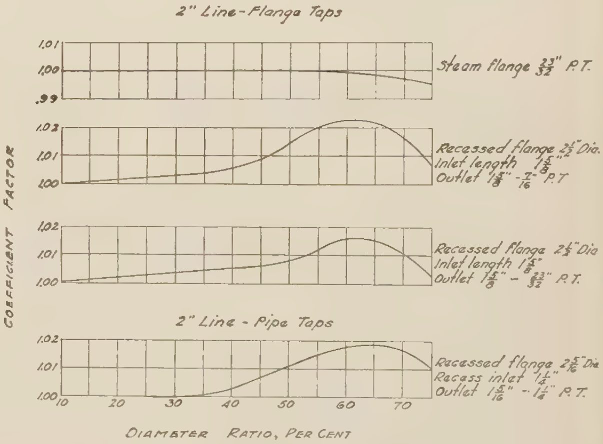


Fig. 8 Effect on Flange Taps and Pipe Taps in a 2-In. Line

taps are to be used with an accuracy of 0.5 per cent in this size line, it can be seen that the orifice diameter must be held below 35 per cent, and for high accuracy no cored flange should be used. It appears that for flange taps, the use of $^{23}/_{32}$-in. pressure taps has no effect on the coefficient of orifices with diameter ratios of less than 50 per cent, and the effect is only 0.5 per cent for an orifice with a diameter ratio of 75 per cent.

Effect on Pipe Taps in a 2-In. Line. For the pipe taps, the tests were only run on one cored flange. Graphical results of these tests are shown in Fig. 8. The shape of this curve is approximately the same as that for flange taps and recessed flanges, although the values are slightly different. However, the same conclusions as to the use of cored flanges with pipe taps can be drawn as were drawn for flange taps.

Effect on Flange Taps in a 4-In. Line. Fig. 9 shows the effect of flange taps installed in a 4-in. line, and also the results of some special tests which will be discussed later.

It will be seen from the first curve that the use of $^{23}/_{32}$-in. pressure taps in the place of $^{1}/_{4}$-in. taps had little effect on the coefficient of the orifices. The maximum difference was about 0.2 per cent for a diameter ratio of 80 per cent.

The use of the recessed flange caused an increase in the coefficient.

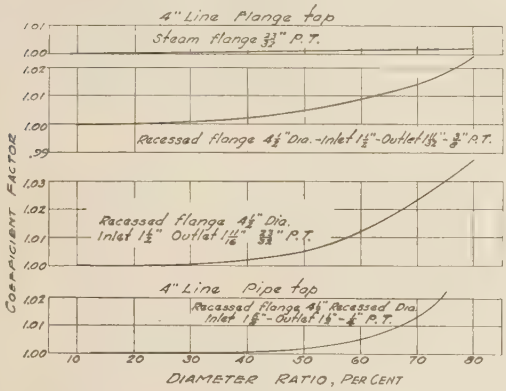


Fig. 9 Effect on Flange Taps and Pipe Taps in a 4-In. Line

cient. This increase started at a diameter ratio of about 30 per cent and amounted to about 0.5 per cent at a diameter ratio of 50 per cent, and rose to a maximum of about 2.4 per cent when the pressure-tap hole in the recessed flange was $^{3}/_{8}$ in. diameter. With $^{23}/_{32}$-in. pressure taps this maximum value rose to about 3.8 per cent.

It would appear that on this size line the use of the cored flange had two effects. The first was to increase the turbulence and so increase the orifice coefficient, and second, because of this turbulence, to build up the upstream pressure, which would also increase the coefficient. This would be more apparent when the larger pressure taps were used, since the larger taps would place the edge of the hole closer to the orifice.

It would appear from these tests that cored flanges should not be used in any case for orifices with a diameter ratio greater than 50 per cent, and for extreme accuracy the maximum usable ratio would be 30 per cent.

Effect on Pipe Taps in a 4-In. Line. Referring again to Fig. 9, the curve for pipe taps is similar in shape to that for flange taps but the deviation of coefficient does not start until a diameter ratio of 40 per cent is reached, and the maximum value is less than that for flange taps. The difference in coefficient is undoubtedly caused by the difference in flow through the orifice only, since the location of the taps precludes the possibility of the recess having any effect on pressure reading.

Effect of Length of Recess in a 4-In. Line. Fig. 10 shows the effect of changing the length of the recess. These curves, one for flange taps and the other for pipe taps, were obtained by varying the length of the recess, first on the inlet and then on the outlet of the orifice. While the one recess was being changed in length, the other side of the orifice was used with a steam-type flange. These curves show that the core on the outlet of the orifice had no effect on the coefficient for either flange or pipe taps. They also show that for the range tested, the length of the recess was the controlling factor of the effect on the coefficient, the longer the recess the greater being the effect. This was true for both flange and pipe taps, although the amount of the effect

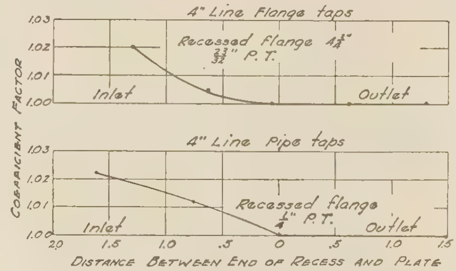


Fig. 10 Effect of Changing the Length of Recess in a 4-In. Line

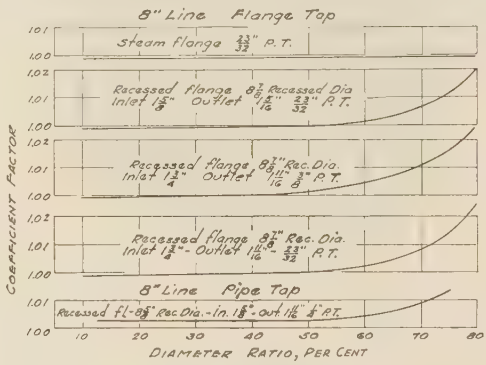


Fig. 11 Effect of Various Installations in an 8-In. Line

was greater for flange taps than it was for pipe taps. This was expected from the other tests since the flange-tap holes were $^{23}/_{32}$ in. diameter. It is also apparent from these curves that a $^{1}/_{4}$-in. gap between the orifice and flange has practically no effect, and this fact makes the construction of a satisfactory orifice flange simpler than it would be if it were necessary to have the end of the pipe flush with the face of the flange.

Effect on Flange Taps in an 8-In. Line. Fig. 11 shows the results of the tests on the 8-in. line. These curves are quite similar to those for the 4-in. line, and again are of the expected shape. It will be noted that apparently there was a difference of about 0.1 per cent between the $^{1}/_{4}$-in. and $^{23}/_{32}$-in. pressure taps, and that this difference carried through the whole set for the orifices with lower diameter ratios. This difference may well be experimental error, but since it was consistent for all tests, it was shown on the curves. The recess on this size line caused no appreciable error for orifice-diameter ratios of less than 50 per cent, and the effect was less than 0.5 per cent for a diameter ratio of 60 per cent, increasing to about 2.5 per cent for a diameter ratio of 80 per cent.

Effect on Pipe Taps in an 8-In. Line. The one apparent difference between the lower curve and the rest of the curves in Fig. 11, is the fact that there is a constant difference of about 0.3 per cent between the two coefficients at low ratio. This

is probably due to several things. First, because of seasonal conditions it was impossible to get extremely high flows through the plates and it was necessary to extrapolate some of the curves. Second, the steam flange for this line was made by putting filler rings in recessed flanges and it was difficult if not impossible to get the filler rings in the same at all times, so as to make a smooth approach. These facts probably account for this difference in all ratios and the shape of the curve represents the effect of the recess. If this is true there is no deviation of the coefficients until a diameter ratio of 55 per cent is reached, and the deviation is only about 0.5 per cent for a diameter ratio of 70 per cent.

Conclusion

The committee, in making its report, made the following recommendations concerning orifice flanges. It was recommended that the orifice pipe extend through the flange so that there is no recess greater than $^1/_4$ in. between the orifice plate and the end of the pipe, as measured parallel with the axis of the pipe. ...If in existing installations there is a recess preceding the orifice plate, either in the orifice flange or between the pipe and the plate, the length of which parallel to the axis of the pipe is greater than $^1/_4$ in., the orifice coefficients given in this report may be used only if the ratio of the orifice to pipe diameter does not exceed 0.3 for a 2-in. line, 0.4 for a 3-in. line and a 4-in. line, and 0.5 for all lines greater than 4 in.

Orifices installed according to the recommendations would then, from the curves shown, have a maximum error of coefficient of about 0.25 per cent if the maximum diameter ratio were used and less for smaller diameter ratios.

A study of all of the curves will show that the general shape of all is the same, but that there is considerable difference in the detail shape of the curves after the deviation in coefficient has started. This is probably due to the effect of different shapes and sizes of recesses, and shows that it is impossible to predict what correction to use if a diameter ratio higher than those given is used.

It is realized that this graphical method of study of the results may have some defects, but it was by far the simplest method available, and since the number of data available was very large, it appeared to be the only practical method. In actual comparison it could be shown that there was a variation of expansion factor between the two orifices in addition to the variation of coefficient and it might be thought that this would affect the results. This variation was there due to the fact that the pressure was always less at the commercial flange than it was at the reference flange. However, since the comparison was not made between the reference orifice and the recessed orifice directly, but between the orifices in a steam-type flange and in a cored flange, using the reference orifice as a base, the expansion factor should be so nearly the same for similar conditions that it would cancel out. With these facts in mind it is felt that the curves shown in this paper should accurately indicate the effect of the various conditions studied.

Cemented Carbide-Fitted Saws and Woodworking Knives

By C. M. Thompson,[1] Philadelphia, Pa.

The author reviews the development of the present design of carbide-fitted saws and gives some standard tooth angles required for various materials. Certain recommendations are made for the application of cemented carbides to woodworking knives and for the operation of carbide-fitted saws and knives on wood. Savings effected by the use of Carboloy saws are tabulated by the author.

In the early application of tungsten carbides to saws, it was natural that the inserted-tooth saw should appear first because of the comparative ease of brazing the carbide tip to the steel insert which in turn could be inserted in a hardened and tempered blade.[2] Such a saw is shown in Fig. 1. It soon became apparent, however, that tooth spacing closer than that possible with the inserted-tooth saw was necessary, particularly for smooth cutting and the sawing of thin bakelite and other abrasive materials which rapidly dull the steel saw. After several years of experimental work saws have been produced successfully in which the carbide tips are brazed directly to the steel blade, and in which the minimum tooth spacing is approximately $^5/_{16}$ in. These saws are now manufactured in diameters up to and including 16 in. Where larger diameters are required it is necessary to revert to the inserted-tooth saw. The solid-tooth carbide-fitted saw is shown in Fig. 2.

The widespread use of carbide-fitted saws has been somewhat curtailed by the cost and time required for sharpening. There are, in general, three forms of teeth required to meet the successful sawing of a great variety of materials on the market today. These tooth forms may be classified as (1) straight front, (2) alternate bevel, and (3) square and advanced.

These forms are shown in Figs. 3 to 7, inclusive. It can be seen that the alternate-bevel and square-and-advanced forms offer more difficult sharpening problems than the straight-front form. While the square-and-advanced form is primarily a metal-cutting design, the alternate-bevel form is necessary for sawing materials of a fibrous nature where a shear cut is essential for smoothness. The straight-front form is designed for sawing bakelite, hard woods, and other dense materials.

When it is considered that teeth with the alternate-bevel form are manufactured with extreme rake or undercut angles of 20 deg, alternately beveled faces of 30 deg, and alternately beveled tops of 25 deg, the acuteness of the points of the teeth becomes apparent. Former sharpening practice required the grinding of the carbide teeth followed by diamond lapping, which was a slow and costly procedure. Fortunately, the introduction of bakelite wheels impregnated with diamonds, which are now available in standard sizes and shapes, has materially decreased the sharpening time. These wheels not only cut faster than the grinding wheels but at the same time produce a cutting edge almost the equal of the diamond-lapped edge.

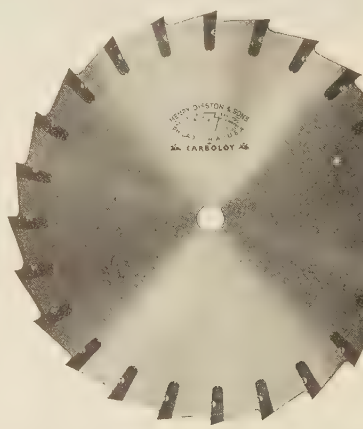


Fig. 1 Inserted-Tooth Carbide-Fitted Saw

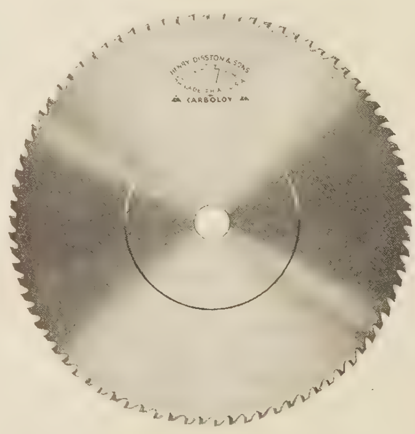


Fig. 2 Solid-Tooth Carbide-Fitted Saw

It is somewhat difficult to establish standard angles for carbide saw teeth even for definite materials, due to the fact that the position of the material to be cut relative to the saw governs the amount of rake angle required. For example, a saw used on a regular wood-saw bench for use on bakelite would require a rake angle of 12 or 15 deg on the teeth, whereas a saw used on a machine having an overhead arbor would require either a radial or zero

[1] Assistant Manager of Sales, Industrial Division, Henry Disston & Sons, Inc. Mr. Thompson was graduated with a B.S. degree from the University of Pennsylvania in 1915, and received an M.E. degree from the same University in 1929. From 1925 to 1929 he was plant engineer with Henry Disston & Sons, Inc., and from 1930 to 1933 he was products engineer with the same company. He was transferred to the Industrial Sales Department of the company in 1933.

[2] "The Application of Tungsten Carbide to Circular Saws," by C. M. Thompson, *Mechanical Engineering*, vol. 52, July, 1930, p. 681.

Contributed by the A.S.M.E. Special Research Committee on Cutting of Metals and presented before the Wood Industries Division at a meeting of The American Society of Mechanical Engineers held at Niagara Falls, N. Y., September 17 to 19, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until April 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

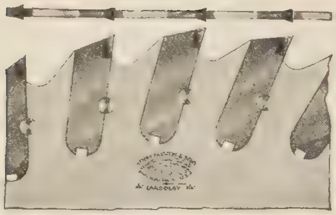


Fig. 3 Inserted Straight-Front Tooth

Fig. 4 Inserted Alternate-Bevel Tooth

Fig. 5 Inserted Tooth of Square-and-Advance Form

Fig. 6 Solid Tooth With Alternate-Bevel Form

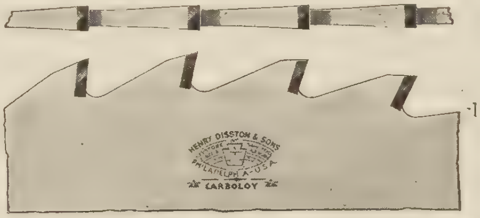


Fig. 7 Solid Tooth With Straight-Front Form

rake angle on the teeth, or teeth having a negative rake angle of 5 to 10 deg. In general, the tooth angles listed in Table 1 can be recommended.

In order to simplify manufacturing cost and reduce sharpening costs, the teeth of carbide-fitted saws are designed so that it is only necessary to apply the grinding or lapping wheel to the carbide tip. This is accomplished by originally grinding the angle of the steel back of the tip about 2 deg greater than the angle on the carbide, thereby eliminating the necessity for grinding or lapping the steel. The sharpening of carbide-fitted saws is a hand operation and cannot be accomplished on an automatic saw-sharpening machine. It is necessary to bring the diamond lapping wheel into contact with the carbide tip and then feed the wheel in a reciprocating manner across the tip. Fig. 8 is a diagrammatic sketch of a sharpening machine which the author recommends for sharpening carbide-fitted saws. It is possible, however, to sharpen these saws on a universal tool grinder, but it should be kept in mind that any machine used for this work must be rigid and free from end play in the spindle.[3]

TABLE 1 RECOMMENDED TOOTH FORMS AND TOOTH ANGLES FOR CUTTING DIFFERENT MATERIALS[a]

Tooth form	Material to be cut	Rake angle, deg	Top angle, deg	Alternate-bevel, deg
Straight-front	Bakelite	12	15	..
	Hard wood	25	18–20	..
	Hard rubber	15	15	..
Alternate-bevel	Cardboard	20	18	30
	Masonite	10	20	30
	Celotex	20	20	30
	Plywood	20	18	30
Square-and-advanced	Aluminum	15	15	..

[a] Recommended forms and angles to be used on saws mounted on a regular saw table with arbor below the work.

The application of cemented carbides to woodworking knives is a comparatively simple one, and if certain fundamentals are adhered to, successful performance can be assured. Fig. 9 illustrates the recommended practice for standard knives. It should be carefully noted that the included angle should not be less than 50 deg. For this reason carbide-fitted knives are not recommended for use in square heads. The carbide tip should be kept as thin as permissible so as to avoid too great a portion of unsupported tip.

The most successful setup for tongue-and-groove cutters and other similar patterns can be obtained by breaking up the cut with individual cutters rather than by attempting to apply cemented-carbide tips to the generated-type cutters. In the first place the generated-type cutter is difficult to manufacture with carbide tips, and is costly. If breakage occurs due to striking some foreign object, such as a nail or a hard loose knot the entire cutter is ruined, whereas the single cutter, on the other hand, is easy to manufacture, is considerably cheaper, and if an accident occurs the chances are that only one or two cutters will be damaged. Figs. 10 and 11 show recommended types of tongue-and-groove carbide-fitted cutters, while Fig. 12 shows the generated type of knife.

Carbide-fitted knives should not be recommended for heads requiring corrugated or serrated backs for the reason that it is practically impossible to fit them in the heads so they will track at full speed; nor can they be jointed in the head as is done with steel knives. Plain or smooth-back carbide-fitted knives can be adjusted so they will track. While these knife recommendations mean longer setup time they are based on actual experience and if followed will result in satisfactory and economical performance.

The limits to the length of cemented carbide-fitted knives are governed by the ability to manufacture straight carbide tips of thin sections. So far as intricate shapes, such as molding

[3] "Care and Maintenance of Carboloy-Tipped Saws," by C. M. Thompson, *Carboloy*, vol. 2, May, 1930, p. 18.

TABLE 2 ECONOMIES RESULTING FROM USE OF CEMENTED CARBIDE SAWS

Material cut	Chestnut board[a]		Celotex[b]	
Type of saw	Steel	Carboloy	Steel	Carboloy
Amount of material cut per sharpening, ft	750	200000	5000	530000
Initial cost of saw	$5.04	$179	$7.50	$158
Cost of sharpening (per time)	$0.50	$18	$0.40	$15
Number of sharpenings per life of saw	30	15	25	12
Amount of material cut in total life of saw, ft	22500	3000000	125000	6360000
Total saw cost, including sharpenings	$20.04	$449	$17.50	$338
Saw cost per 1000 ft of material	$0.89	$0.149	$0.14	$0.053
Number of saw changes per 1000 ft of material cut	1.33	0.005	0.2	0.0018
Down time 3 min per change at 40 cents per hr	$0.0266	$0.0001	....	....
Down time 5 min per change at 40 cents per hr	....	....	$0.0066	$0.0000594
Total cost per 1000 ft of material cut	$0.9166	$0.1491	$0.1466	$0.053

[a] Saving per 1000 ft, disregarding increased production due to less down time = $0.7675.
[b] Saving per 1000 ft, disregarding increased production due to less down time = $0.0936.

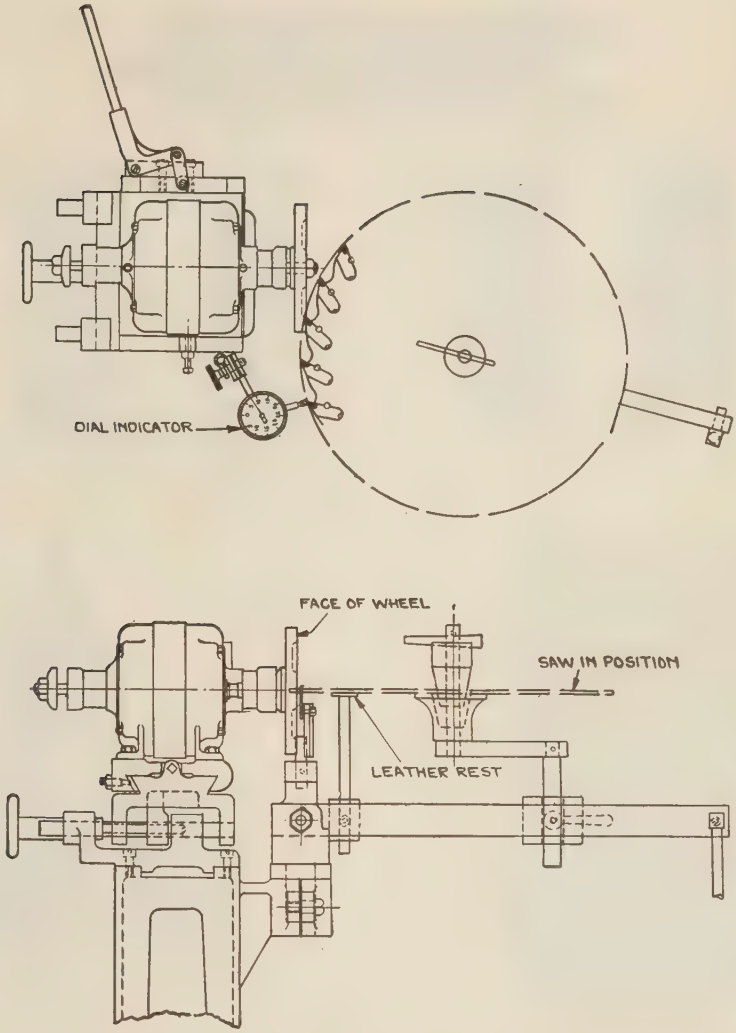


Fig. 8 Type of Grinder Recommended for Sharpening Carbide-Fitted Saws

knives, are concerned it has been proved that these can be manufactured successfully; the limiting feature being cost. Whether they can be justified depends to a great extent upon the amount of material, of a given shape, to be produced.

With carbide-fitted knives, as with saws, the sharpening costs have been greatly reduced by the introduction of bakelite wheels impregnated with diamonds. Hand sharpening of carbide-fitted knives should never be attempted. They should be held in a vise at the proper angle and sharpened on a universal or other tool grinder of rigid construction and free from loosely fitted bearings and end play in the spindle. Table 2 shows the economies to be derived from the use of cemented-carbide saws.

Some of the materials for which cemented-carbide saws and knives are recommended are: Asbestos pipe covering; bakelite, micarta, and textolite; chestnut board; corrugated container stock; celotex; enameled picture-frame stock; fiber; fireproof wood; linoleum; linoleum-covered plywood; masonite; molded brake lining; plywood and glued stock; and oriental walnut. Broader use of cemented carbide-fitted saws and knives is increasing yearly as new synthetic materials and wood substitutes of an abrasive nature are introduced, and the users of these

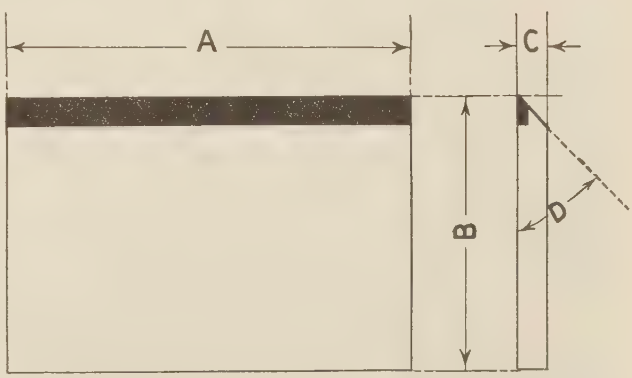


Fig. 9 Dimensions of Carbide-Fitted Knives for Wood Saws

(Dimension *A* cannot be less than 6 in.; *B* cannot be more than 5 in.; *C* cannot be less than 3/16 in.; and *D* should not be less than 50 deg. Carboloy-fitted knives are usually made as follows:

Up to 2 in. long.............. 1/4 in. thick with Carboloy 3/32 × 1/4 in.
Over 2 in. long, including 3 1/2 in. 1/4 in. thick with Carboloy 1/8 × 1/4 in.
Over 3 1/2 in. long, including 5 1/2 in. 5/16 in. thick with Carboloy 5/32 × 5/16 in.
Over 5 1/2 in. long, including 6 in. 3/8 in. thick with Carboloy 3/16 × 5/16 in.)

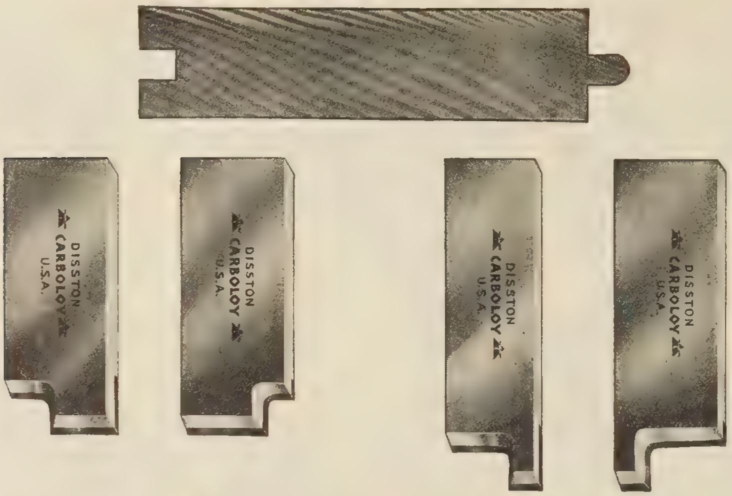


Fig. 10 Tongue-and-Groove Cutters

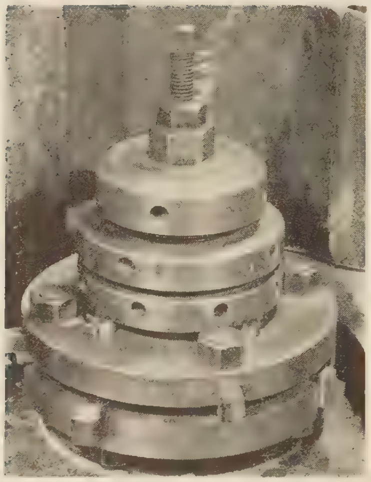


Fig. 11 Tongue-and-Groove Cutters Set in Cutting Head

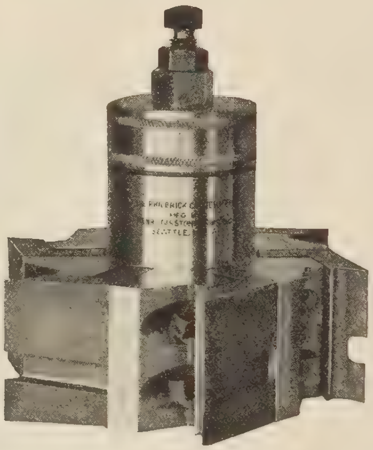


Fig. 12 Six-Knife Generated-Type Head for Working 2-In. and 3-In. Flooring

tools become more familiar with their use, care, and maintenance.

Cemented Carbide Saws for Woodworking

The application of cemented carbide-fitted saws and knives to ordinary woodworking has been somewhat retarded by the high initial cost and the lack of proper sharpening equipment, as well as by the inability of toolroom labor to learn the procedure. Where woods of an abrasive nature have had to be worked, or where glued stock was a large percentage of the production, some very interesting and cost-reducing applications have been made.

Little progress has been made in the application of carbide-fitted saws to straight-line rip machines for two very pertinent reasons. First, the saw must be of the inserted-tooth type with a hardened and tempered blade to withstand the strains to which the blade is subjected by the passage of warped lumber in the mechanical feed. Second, practically all straight-line ripping is for glued joints, and the cut obtained from the inserted-tooth saw is not sufficiently smooth for this purpose.

Carbide-fitted saws also are not suitable for edging veneers, because it is not possible to have the tooth spacing close enough, with the result that the cross-grain cut is usually poor, often breaking out the grain from 0.25 to 0.5 in. from the cut.

One of the most successful applications of carbide-fitted saws is for sizing plywood linoleum-covered table tops. On this application these saws are known to produce as much as 13,000 linear ft of material before requiring sharpening.

In the application of cemented carbide-fitted knives, particularly for molding (which is of glued stock probably having oriental walnut veneer), it is not necessary to have the entire intricate shape of the knife faced with the carbide. This is particularly true where there is not sufficient production to justify the initial cost. All that is necessary is to apply the carbide to a small knife or bit in the head which will take the glue line and the oriental veneer, and use high-speed-steel knives which are easily formed to shape for the balance of the molding form. Such a setup may well be applied to radio-cabinet production. The same carbide bit or knife may be used with a combination of form knives whenever it is necessary to change the pattern.

The author believes that many production shops overlook the possibility that increased production through less down time for sharpening and knife changes can be obtained by applying cemented carbide to the knife where it is required rather than attempting to apply the carbide to the entire form of the cut, which in most cases results in a very costly tool and, therefore, cannot be justified. Broader and correct use of cemented carbides in the woodworking industries will undoubtedly result in lower production costs and greater profits.

Discussion

Automatic Regulators, Their Theory and Application[1]

J. B. McMahon.[2] Automatic control at the present time is by no means a science but is in that indeterminate state where it is gradually changing over from an art to a science. The state of the art at the present time is such that any general approach to it should be such that it will very carefully include the experiences and opinions of all of the groups which are interested or may be affected; otherwise some of these groups may find themselves later on forced to engage in a vigorous struggle to establish the validity of their own experiences, viewpoints, and terminology. On that account the writer believes that a paper such as this should be representative of as wide an experience as possible and should be collective rather than individual.

There is at present no general agreement in terminology in the broad field of automatic control and no generally accepted definition of the desirable qualities of automatic regulators. The author attempts to fill this gap.

Mitereff's recent paper[3] covered the theoretical analyses of types of automatic controllers quite adequately, although he betrayed his unfamiliarity with the practical accomplishments in recent years in this field.

In the present paper, the author lists what he considers the four desirable qualities of an automatic controller, as (1) power, (2) speed, (3) sensitivity, and (4) stability. This order may not be the author's order, but he rates them all equally, so that the order of their listing is not relevant. The author also attempts to define each of these.

Of these desirable qualities, speed and power are very easy of definition. Stability is not so easy to define and is not clearly defined by the author. Stability is a combination of qualities of the controlling device which must be considered with respect to the control problem under consideration. It cannot be considered as a separate entity.

Sensitivity is capable of two definitions which are frequently confused. It may be defined as the smallest quantity of change to which the device in question is capable of responding in any degree; or it may be defined as the unit change of response per unit change of effect being measured. The author uses the first of these definitions but the second one is in very common use with respect to a control quality in a very large section of industry. Its use in this respect is not any too clearly defined and a clearer definition of its use in this respect is probably in order, but it is used in this manner and should not be disregarded.

Aside from this lack of clarity of definition by the author, the writer would like to point out that, except in specific instances, only one of these qualities listed by the author is necessary. This is power.

Speed is unnecessary in a large percentage of automatic-control installations. It should be remembered that the writer is referring to the broad general field of automatic control. The rate of change of the regulating device (valve, rheostat, motor, damper) is not important on a great many temperature-control jobs.

Stability, if considered from the standpoint of the operation of the controlling device itself, is not only unnecessary on a great many installations, but can very definitely be detrimental to successful results. To achieve successful control on many jobs and maintain the controlled effect constant, a fundamental instability must be built into the controller itself. Again, many temperature-control installations fall within this classification. In all probability more temperature controllers are sold that are fundamentally unstable than otherwise.

Sensitivity, considered from either of its definitions or both, is again a quality that must be considered with respect to the specific application under consideration. Many liquid-level controllers are made purposely insensitive from the first standpoint, having a "dead spot" purposely built into them and the increasing use of averaging-type level controllers testifies to the desirability of controllers which are intentionally built to be definitely insensitive from the second standpoint.

Therefore, it seems to the writer that instead of clarifying the subject of automatic control and its terminology, this paper[1] still further obscures it. A paper which was the result of group rather than individual effort would undoubtedly have cleared up some of the foregoing points. Also, the writer would like to reiterate that the technical handling of this subject within the next few years is going to be either very helpful or very harmful, according to the manner in which it is handled and every precaution should be taken by students of the subject to assure thorough representation of all points of view.

G. W. Smith.[4] A well-balanced criticism of the author's paper, citing those points on which agreement should be universal, those which are debatable and those which are clearly wrong, would be a considerable undertaking, far exceeding the time or space available for this discussion. Suffice it to say that there are 304 sentences in this paper, representing all three categories.

As to the first category, which in importance and general interest probably outweighs the rest; the author has done well to bring to the attention of his audience the fact that precise analysis is not only desirable but necessary for the successful application of automatic control; that behind appearance, size, popularity, and price of regulators lie factors of more basic importance, and that combined efforts of manufacturers and users to help each other see their problems alike would be advantageous. The writer thinks that greater progress must be made before a committee can successfully standardize industrial regulators according to the author's or any other classification, but nevertheless would be glad to see such a joint effort made if discussion appears to make it worth while.

The place to begin, however, is not with what the author calls the controller, or, which is worse, with the metering element, but rather with the problem to be solved. The author neglects all but two types of simple control, which he characterizes as having "process lag" and not having it. In actuality there is a much more important basis for classification, viz., the presence or absence of "self-regulation," to which the writer will refer again.

[1] Published as paper PRO-58-4, by Ed S. Smith, Jr., in the May, 1936, issue of the A.S.M.E. Transactions.

[2] Manager, Controller Division, The Foxboro Company, Foxboro, Mass. Mem. A.S.M.E.

[3] "Principles Underlying the Rational Control of Automatic-Control Regulators," by S. D. Mitereff, Trans. A.S.M.E., vol. 57, May, 1935, paper FSP-57-9, p. 159.

[4] General Manager, Hagan Corporation, Pittsburgh, Pa. Mem. A.S.M.E.

Secondarily we have control problems in which (1) there is no lag between throttle movement and final effect thereof; (2) the final effect is delayed as in the author's Figs. 6 to 12, inclusive, but the first derivative of the effect is without lag; (3) the effect and its first derivatives lag, but higher derivatives do not, as discussed in Mitereff's paper;[3] and (4), there is a definite lag between movement of throttle and any palpable response whatever. The latter is common in temperature regulation. A lot has been published, publicly and privately, in this country about the metering end of automatic control, but when it comes to the matter of time lag, and excepting Mitereff's paper,[3] there seems to have been much thinking and but little thought.

From sentence 23 to sentence 301, inclusive, of the paper, there is much with which to agree, but also much with which to differ. Exception must be taken to the author's concluding remarks, from which it can be inferred, perhaps unintentionally, that maintenance and operating costs of air-operated controllers exceed those of hydraulic and electrically operated equipment. The contrary is true as to maintenance costs and, with one exception, as to operating costs as well. This of course, is especially true of combustion control.

The writer next observes that the author indicates no acquaintance with a work which has consistently been treated with a neglect that is exceeded only by its worth. Reference is made to Stein's "Regelung und Ausgleich in Dampfanlagen"[5] which, published in 1926 and followed in 1928 by the enunciation of the law of self-regulation,[6] has advanced the literature even beyond the state of the art. The writer is unable to comprehend why Messrs. Behar and Mitereff and now the author have missed or at least failed to mention this work. While ingenuity can often be displayed in devising regulators which will recognize rates of change, their complete equations of motion can only be derived by using the principles set forth by Stein.

Our American literature on control equipment suffers from what might be called "instrumentitis." Too many people have tried to solve control problems by adding a motor to a meter, and when trouble resulted, have tried to escape it by devising more and more complicated metering elements. Lame and halting regulator performance can seldom be corrected by complicating the pressure-sensitive element.

The author's discussion of "stability" represents an impossible oversimplification. His Fig. 2 may correctly represent the behavior of a meter having some inertia, if it be remembered that the second derivatives are discontinuous, or even that of a governor where inertia effects are great and self-regulation usually quite large; it does not follow that in general the hunting of a relay-type pressure regulator can be reduced by adding static friction either to the meter or to the controller. The direct contrary is in fact true as can be demonstrated theoretically with great labor, but without any difficulty experimentally.

Directly in this connection, and because of its bearing on "insensitivity," the writer must point out that the expression $x = —ky$ which the author uses frequently, cannot be correct unless the rate of outflow varies with the pressure ("self-regulation"), which is contrary to his assumptions. To see this clearly we need only replace his water jet by a reciprocating pump, or well-governed prime mover, whereupon the regulator shown in Fig. 3 of the paper will be unstable despite the zero storage lag and will require a spring inside the dashpot to make it theoretically stable. The correct expression is $dx/dt = —(1/k)(y — y_0)$ where y_0 is the valve opening at equilibrium; k is small for zero process lag and great for large process lag. The author's discussion of Fig. 3 misses the point; the equation he obtains and on which he bases his subsequent argument owes its decaying solution not to a small process lag but to the exaggerated self-regulation implied by $x = —ky$.

A proper criterion of the dead zone within which a regulator will come to rest is quite complex and must contain terms which recognize self-regulation. Putting more lap into pilot valves will not stop hunting unless there is a high degree of self-regulation, and then only if the metering element have some source of gradient or spring force. Lap, friction, and constant-speed motor operation are much alike when considered dynamically.

The author's tentative classification of regulators possesses the merits of novelty and simplicity; the writer believes it would provide a sound basis for expansion. He is, however, at a loss to account for the operation of Class XII regulator. He can only assume that the figure is incorrectly drawn.

On the basis of the author's simplifying assumptions, the performance of his Class VI regulator is identical with that of his Fig. 3 and Class IV regulator, provided that, as is always the case with the simple fluid-relay regulators shown, the pilot valve opens gradually. If one sets up the equations they will be found to have corresponding terms and to differ only in constants and not in order; the dashpot and the spring are dynamic equivalents. If the author intended Classes III and IV to typify electrically operated regulators, it would have been better so to show them. If, on the other hand, the pilot valve does open abruptly, Class IV is identical with Class III, unless there is lap.

There is some confusion in the description of the Class III regulator. It appears that the author has integrated when he should have differentiated. In his description he states that $dy/dt = \pm k$, but the curves show that $dy/dt \neq \pm k$ but rather $dy/dt = f(t)$.

This confusion becomes more evident in his description of Classes VI and VII. We present below the complete equation for a Class VII regulator; here we point out only that Class VI is inherently unstable with any finite storage lag, whether the variations in outflow are slow or fast. Changes in outflow rate brought about by external agencies lead to particular solutions of the equations; if the general solution describes an unstable motion, the regulator will not even be transiently stable.

The writer presents the author's Equation [44] as

$$b\frac{d^2y}{dt^2} + (K + c)\frac{dy}{dt} + ky = 0 \text{ (} K \text{ is spring constant)}$$

which is true only if $x = —ky$, which, in turn, is impossible in the figure shown.

When we admit the storage lag, we must set $\frac{dx}{dt} = —K'y$ and

$$b\frac{d^3x}{dt^3} + (k + c)\frac{d^2x}{dt^2} + K'y = 0 \dots\dots\dots [1]$$

There is no term in dx/dt and the equation demonstrates that the pressure variations increase with time.

Yet such regulators may be stable. Their stability is not derived from the insensitivity, which the author credits with this ability, but from factors ignored in his treatment. One such source from which stability may be derived is the variation in output rate which accompanies variation in pressure; an effect which the author explicitly rules out in his Equation [25] and consistently neglects throughout his paper. This variation supplies the missing term in dx/dt. Thus

$$\frac{dx}{dt} = —K'y — K''x \text{ .}$$

[5] "Regelung und Ausgleich in Dampfanlagen," by Th. Stein, Julius Springer, Berlin, 1926.

[6] "Selbstreglung, ein neues Gesetz der Regeltechnik," by Th. Stein, *Zeit. V.D.I.*, vol. 72, January–June, 1928, pp. 165–171, and 209–214.

where we follow the author's convention of neglecting certain constants. This leads to

$$b\frac{d^3x}{dt^3} + (bK'' + k + c)\frac{d^2x}{dt^2} + (k + c)K''\frac{dx}{dt} + K'x = 0 \quad [2]$$

Stable regulation is possible when

$$bK''^2(c + k) + K''(c + k)^2 - K'b > 0 \quad [3]$$

This is a very important relationship, and displays the advantage of decreasing the value of K', or the ratio of increment of input to movement of control valve, to the minimum consistent with the conditions of the problem.

Of course numerical evaluation of this criterion of stability would be meaningless due to the simplifying assumptions; precise results are most easily obtained by the use of Stodola's time constants.

Regulators of author's Class VII may not be stable in operation even though constructed of parts without mass, having no metering lag except that due to simple damping, and doing no work except on the dashpot. To see this qualitatively we need only imagine the reset spring as of infinite stiffness. In this case Class VII becomes equivalent to Class VI which is inherently unstable regardless of process lag so long as there is no self-regulation. Therefore, the spring stiffness must not exceed a certain finite value. On the other hand, with a reset spring of zero stiffness Class VII becomes equivalent to Class IV which is likewise unstable. Therefore, the spring stiffness must lie within certain extreme values.

Assuming a spring of optimum stiffness, it is obvious that a dashpot with zero damping will still give us a Class IV regulator which will be unstable. A dashpot with infinite damping produces a variant of Class V, which is, from the standpoint of stability, the most satisfactory of all simple regulators.

Clearly, for best results, the damping and stiffness must be selected from a range of possible values.

These somewhat vague ideas, which like the author's presentation of Class VII are purely qualitative, may be made exact. It will, the writer believes, be worth while to derive the equations of motion of regulators of this class, using time-constants where expedient, and examining more closely than does the author the validity of the assumptions. The author's symbols will be used where possible.

A start is best made with the equipment to be controlled. We replace the author's outlet jet with a reciprocating pump in order to eliminate the self-regulation of varying discharge. Then, letting Y = opening of inlet valve measured positively from the closed position; Y_e = opening of inlet valve necessary for equilibrium at any outflow, $Y_{max} = 1$ = maximum opening necessary for equilibrium with maximum outflow, X = absolute pressure in feet of water, and X_s = set value, we have

$$\frac{dX}{dt} = \frac{1}{K}(Y - Y_e) = \frac{1}{K}\,\Delta Y$$

or

$$X_s\frac{dx}{dt} = \frac{1}{K}\,y$$

where $y = \dfrac{\Delta Y}{Y_{max}}$ and $x = \dfrac{X - X_s}{X_s}$

It will be convenient to say that $X_s = 1$, and to measure pressures in terms of this unit, rather than in feet of water. With this convention

$$K\frac{dx}{dt} = y \quad [4]$$

and K is the time required to change the pressure by unity (X_s feet of water) when $\Delta Y = Y_{max} = 1$. We will call K the "storage time" and designate it by T_s where T_s is the quantitative measure of process lag in this simple type of regulation.

We next assume that our regulator and valve are such that Y_{max} is the full stroke. If, as is often the case, the valve is too large and the regulator is connected to open it fully, all constants must be corrected accordingly, and stability is proportionately more difficult to attain.

The motion z of the controller will be measured from mid position and in such units that when $z = \pm 1$, the pilot-valve ports will just be fully open, the plus sign being taken for upward movement. Then

$$K\frac{dy}{dt} = -z \quad [5]$$

is the motion of the controller. Unless the controller be sufficiently powerful, not only to position the valve accurately, but also to move the valve with a speed proportional to the pilot-valve opening, the order of our differential equations will be raised by at least one and more usually by two, and new possibilities of hunting arise. Most regulators are deficient in power in this respect.

The term K here is T_c or controller time, that is, the time required for the controller to move a full stroke (Y_{max}) with the pilot valve fully open ($z = 1$).

Combining Equations [4] and [5] of this discussion

$$T_s\,T_c\frac{d^2x}{dt^2} = -z \quad [6]$$

Designating by F, the tension in the reset spring and equating forces on the pilot valve, we get

$$x - b\frac{dz}{dt} - k_1z - F = 0 \quad [7]$$

from which the constant terms representing forces due to X_s have been canceled. We replace b by T_m, the metering time, the definition of which will almost be obvious. In numerical calculations k_1 must be expressed in units of pressure ($X_s = 1$) required to compress the spring the distance necessary to open the pilot valve. Combining Equations [6] and [7]

$$T_mT_sT_c\frac{d^3x}{dt^3} + k_1T_sT_c\frac{d^2x}{dt^2} + x - F = 0 \quad [8]$$

To determine F, let w be the position of the dashpot piston (w positive upward) measured from its equilibrium position with $z = 0$. Then

$$F = k_2(z - w) \quad [9]$$

is one expression for the spring tension, which we will substitute in Equation [8]. Hence

$$T_mT_sT_c\frac{d^3x}{dt^3} + (k_1 + k_2)\,T_sT_c\frac{d^2x}{dt^2} + x + k_2w = 0 \quad [10]$$

Another expression for F is

$$F = K\frac{d(w - cy)}{dt}$$

constant c being introduced because of the different units in which w and y are expressed. This gives

$$F = T_{d_s}\frac{dw}{dt} - T_{d_y}\frac{dy}{dt} \quad [11]$$

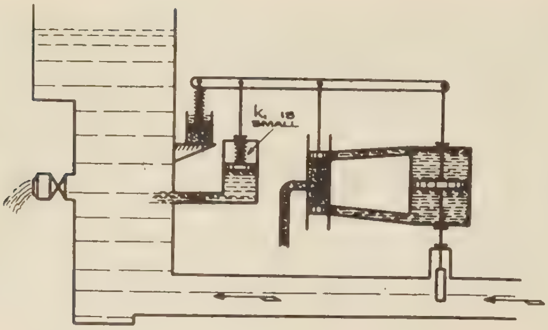


Fig. 1 Modified Class VII Pilot-Governed Regulator With a Follow-Up, and a Small Permanent Gradient, but a Larger Temporary Gradient

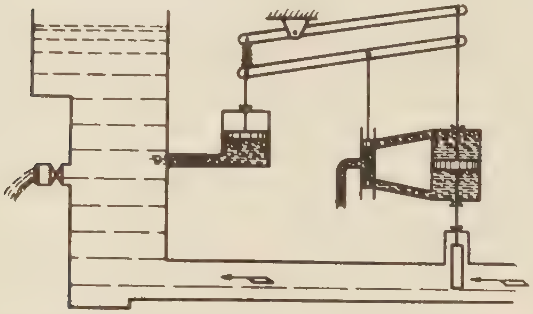


Fig. 2 Modified Class VII Regulator in Which the Gradient Is Dissipated at a Rate Inversely Proportional to T_c

where the time constants represent the times necessary for unity movement of the dashpot piston or cup while maintaining a force balancing X_s. Since $T_{dy} = cT_{ds}$, from the writer's Equations [9] and [11], and by substitution from the writer's Equations [4] and [5]

$$T_s(k_2T_c - T_{dy})\frac{d^2x}{dt^2} + T_{ds}\frac{dw}{dt} + k_2w = 0 \qquad [12]$$

Equations [10] and [12] are simultaneous equations, which may be reduced to the single equation

$$T_mT_{ds}T_sT_c\frac{d^4x}{dt^4} + T_sT_c\left[(k_1 + k_2)T_{ds} + k_2T_m\right]\frac{d^3x}{dt^3} + \left[k_1 + \frac{T_{dy}}{T_s}\right]k_2T_sT_c\frac{d^2x}{dt^2} + T_{ds}\frac{dx}{dt} + k_2x = 0 \qquad [13]$$

The condition that the solution has no positive exponential factor is

$$T_{dy} - \frac{T_mT_{ds}^2}{k_2T_s[(k_1 + k_2)\,T_{ds} + k_2T_m]} - k_2T_c\left(1 + \frac{T_m}{T_{ds}}\right) > 0 \qquad [14]$$

or

$$c - \frac{T_mT_{ds}}{k_2T_s[(k_1 + k_2)\,T_{ds} + k_2T_m]} - \frac{k_2T_c}{T_{ds}}\left(1 + \frac{T_m}{T_{ds}}\right) > 0 \qquad [14a]$$

The prime factor in determining stability is, in the final analysis, the apparently unimportant ratio between travel of dashpot cup and travel of dashpot piston. In the extreme case, where the cup is stationary and there is no self-regulation, the regulator can never be stable. This is not the same as writer's Fig. 1. The writer suggests that the author test this equation by amplifying the movement of the cup in a Class VII regulator. Equations such as these will yield much information of value in design and application.

Class VII regulators in various forms have demonstrated their usefulness over a period of several years. Two modified forms are shown in Figs. 1 and 2 of this discussion. Of these, Fig. 1 is in many respects an improvement; in common with Class VII and notwithstanding the author's disclaimer, such regulators possess the ability to overswing the control point and return gradually without hunting. This ability is lacking in the regulator shown in Fig. 2 of this discussion, but in many applications it is the full equivalent of Class VII.

John J. Grebe.[7] Those familiar with the control problems in industry have met the endless confusion of terms and explanations that accompany the discussions of what various instruments do and how they do it.

All the work of control instruments is presented as more or less of a mystery. Each manufacturer uses a different terminology, and often deliberately chooses different phrases to avoid the appearance that a given control effect might be similar to that of another manufacturer. As a result, when any one talks with a person versed in the art of automatic control it is necessary to use three or four synonyms with each specialized word in the hope that one of them will be understood. This was necessary in a paper[8] presented to the American Institute of Chemical Engineers in 1933, and reedited by T. R. Olive,[9] and found even more necessary in the oral discussion of the paper, which ended with a plea for some sort of standardization of terminology that might possibly become a basis for a better understanding.

Anyone who realizes what the proper continuous automatic control can do for industry, will never be satisfied with anything less than a thorough understanding and application of this phase of engineering.

H. H. Dow in his Perkins Medal address[10] made a very clear statement of this picture. He was an early pioneer in the development of automatic-control apparatus, and was a great inspiration to the application of this work to processes and apparatus at The Dow Chemical Company.

The writer believes that there is no one individual item of standardization or correlation in which the A.S.M.E. can become more useful and valuable than in this particular development. It applies to every engineering project dealt with in our publications and papers, practically all engineering improvements and developments being based on better and more versatile control. A great deal toward unification has been accomplished by M. F. Béhar,[11] H. L. Young and T. R. Olive[12] and by the author of the paper under discussion.

The explicit and complete information given by the author on each of the various classes of regulators makes it possible to get a much better picture of the working principles of the types of control with which we have not been familiar. It is easy

[7] Director of Physical Research Laboratory, The Dow Chemical Company, Midland, Mich. Mem. A.S.M.E.

[8] "The Control of Chemical Processes," by J. J. Grebe, R. H. Boundy, and R. W. Cermak, Trans. American Institute of Chemical Engineers, vol. 29, June, 1933, pp. 211–256.

[9] "Coordinated Effort Solves Dow's Control Problems," by T. R. Olive, *Chemical and Metallurgical Engineering*, vol. 40, October, 1933, pp. 520–525.

[10] "Economic Trend in the Chemical Industry," by H. H. Dow, *Industrial and Engineering Chemistry*, vol. 22, February, 1930, pp. 113–116.

[11] "Fundamentals of Instrumentation," by M. F. Béhar, Instruments Publishing Company, Pittsburgh, Pa., 1932.

[12] "Chemical Engineer's Handbook," McGraw-Hill Book Company, New York, N. Y., 1934. See Section 17 on "Measurement and Control of Process Variables," p. 1641.

now to correlate the various classes in terms of what they do rather than in terms of the way they do it, with all the experience we have had on our own control equipment, built to meet extreme requirements.

The writer believes that all control effects can be classified under the four basic principles listed as the headings of Table 1.

Metered Control. First is the metered control, that is, the integrating, ratio, or proportioning control, all of which are terms that are used to represent the methods by which various apparatus work in which the flow of the controlled quantity is caused to be regulated by the quantity of the material passed through, independent of the end result. This quantity may be variable, so that, as the primary flow changes the secondary flow must be related or proportioned. This is generally used in combustion work.

Deviation Control. The second main subdivision in the methods of control is the deviation control, also called proportional control, or as by the author, modulating, noncorresponding, or floating control. The deviation control, however, can be very crude and often amounts to nothing more or less than an open-and-shut control which operates the valve fully open and fully closed, and sometimes improved by the use of a by-pass or the like to take away the severity of the changes.

The next improvement in deviation control is to have it opening and closing as the meter calls for more or less, generally at a fixed rate of opening and closing, or an on-and-off control, or a valve-moving mechanism, such as a hydraulic relay or motor-operated valve.

The final improvement in deviation control that makes it a good proportional, modulating or noncorresponding control, is one in which the rate of action of the valve closing or opening it is proportional to the deviation, and which always comes to rest at the very same meter point (point control, one type of floating regulator, algebraic difference).

Many control devices, because of the particular apparatus used, have a drooping characteristic similar to the drooping of the voltages of d-c generators, which the author calls corresponding control. This is a serious criticism of many control apparatus, since that particular property is not desired, except under special conditions where control units are operated in parallel.

This is counteracted very often by what some people call the reset or follow-up with dashpot. This compensation can be taken care of either in the meter or in the responsive instrument itself, or in combination with the control motor, such as shown in the author's paper where the dashpot accomplishes this work.

Storage-Lag Pacer Control. The third method of control is rate, anticipatory, or storage-lag pacer, or process, or capacity, or inventory-lag compensator. This control effect is generally added to deviation control or the combination with metered and deviation control, in order to increase the speed of correction when the indicator is going away from the right value at a rapid rate and to anticipate overshooting when the indicator is approaching the right value at a rapid rate.

This control effect is proportional to the rate of change of the indication, and is typified by Class VII, which incorporates a very high type of deviation control, which is accurately proportioned to the deviation without drooping characteristics because of the dashpot; it is very satisfactory because of the storage-lag pacer. This combination can be made to work on practically any control job, especially if the storage-lag pacer is emphasized sufficiently so that the rate of correction is very high when the deviation is first detected and then tapers off rapidly to the correct valve setting over a period of time roughly proportional to the inventory (capacity, storage) lag.

This storage-lag pacer also runs through a whole range of refinements, sometimes being as crude as in the case of temperature control in which by artificial means the effective temperature around the control unit is increased by various methods, so that the temperature control will anticipate by building up heat in the system before it finally reaches the sensitive element and shuts off the flow of heat to prevent overshooting.

An improved type is shown by the author in his Classes X and XI, where the control point is varied over a period of time proportional to the capacity or storage lag of the system. But the best type is where the sensitive element is located so as to get the effect of the change produced as soon as possible and then actuates the control, not only according to the actual position the indicator has reached, but also according to the rate of change. Generally it is very cumbersome and involves considerable amount of mechanical equipment to have the storage-lag pacer affected by the motion of the final control actuator as in the case of the illustrations given in the paper; but, of course, it can be done that way.

Time-Lag Compensator Control. The fourth and final control method is the time-lag compensator (response-lag-pacer method, transfer, indication, correction, velocity distance, lag compensator) which the writer has called damping control. In order to have this free of the disadvantages pointed out by Mr. Smith in his discussion of Class XII regulators, it should also have in it the ability to delay its action for a time proportional to the amount of the lag.

The writer believes that the only error to be found in the paper is in connection with the discussion on the Class XII regulator, (pilot-governed, phase-shift with reversal at control point). The description is that of a storage-lag pacer or rate control in which the rate of change of setting of the valve is determined by a storage-lag pacer control built into the sensitive element or meter, rather than in combination with the control members or actuators. The illustration given does not agree with the description; first, because it works backward the way it is shown, and second, because it shows a direct-operated valve where the position of the valve is directly determined by the position of the meter, rather than the rate of change of the valve setting being determined by the position of the meter.

If, in the diagram below Fig. 17 of the paper, the dotted line represents the rate at which the correction is taking place, and the solid line represents the rate of flow or the opening of the valve, as in all the other cases, or y of all the other curves, then it is a storage-lag pacer. On the other hand, if one rebuilds the unit as shown in Fig. 3 of this discussion so that the dotted line of the author's Fig. 17 represents the position of the valve or y, then the control effect might be called the delayed-action damping control previously described by the writer,[8] if it is independent of the rate of change, but proportionate to the second derivative of X, and effective only for a period of time measured by the straight time lag.

This method of control also has a whole range of gradations of refinements. The crudest form is called the "kicker" in which an arbitrary overshot is passed momentarily to make up for part of the undercompensated flow that has passed the valve between the time the change occurred and the time that the detector and controller finally do something about it.

In order to make the response-lag compensator satisfactory, and to avoid extreme variations in flow as well as to make its effect proportional to the amount of the lag, and proportional to the deviation, it is necessary to build into it a means for delaying its action. The overbalanced flow then compensates for the amount of uncorrected flow having passed through for an accurately proportioned period of time. It makes the difference between the diagram as shown in the interpretation[9] of our paper[8] by T. R. Olive and the effect of the "kicker." It also makes it possible to get the benefit of cyclical operation or intermittently

TABLE 1 GRADATION CHART OF THE FOUR BASIC CONSTITUENTS OF CONTROL[a]

		I Metered	*II* Deviation	*III* Storage-lag pacer	*IV* Time-lag compensator
		Ratio Proportioning Integrating	Proportional Noncorresponding Floating Modulating	Capacity or inventory lag compensator Anticipatory Rate control	Response-lag pacer Damping control Transfer, indication, and correction lag compen.
100 *A*	All that is available	Metered flow prop. to rate of change + rate of flow + state of inventory	Proportional Noncorresponding Dashpot Point control Algebraic difference	Reset spring on follow-up	Delayed-action damping control
60 *E*	Elemental form of the effect	Metered flow prop. to demand or flow rate + state of inventory	Corresponding Band control tapered, fixed, drooping characteristics	Follow-up	Damping
30 *I*	Imperfect Inaccurately proportioned	Metered flow prop. to state of inventory, e.g., steam pressure	Opening-closing On-off High-low Open-shut	Roughly modifying, indication or control point to overemphasize effect of changes	Kicker
0 0	Omitted	Not incorporated in control system.			
U	Unsatisfactory because of negative effect	Many control apparatus are too abrupt or too slow, i.e., air-operated units often have so much instrument capacity lag and time lag that some of their good points are lost by bad ones.			
—30		Inaccurate	Jerky	Gradual	Late

[a] Also called control effects, methods, types, principles, factors, elements.

TABLE 2 METHODS OF ACTUATING AND DEGREE OF THE FOUR CONTROL EFFECTS LISTED IN TABLE 1

Class of regulator	Factor *I*	Factor *II*	Factor *III*	Factor *IV*
I	0	*dA*	*dE-dEU*	0
II	0	*dE*	*dE-dEU*	0
III	0	*iplA*	0	0
IV	0	*iplE*	0	0
V	0	*iplE*	*pI*	0
VI	0	*iplA*	*pI*	0
VII	0	*iplA*	*pA*	0
VIII	*E*±	*iA*	0	0
IX	0	*iplE*	0	0
X[a]	0	*drA* jerky	*pE*	0
X[b]	0	*irA*	0	0
XI[a]	0	*drA* jerky	*pI*	0
XI[b]	0	*irA*	0	0
XII[c]	0	*dE*	*dE*	*dI*
XII[d]	0	*iplA*	*iplA*	0
Olive[9]	*E*	*irA*	*irA*	*irA*

[a] Snap valve.
[b] Slow valve.
[c] As described by the author.
[d] As described by the writer and illustrated by Fig. 3 of this discussion.
d = direct-acting, either self-actuated or power-amplifying
i = integrating or accumulative action
p = pilot
g = gas—air
l = liquid—oil
r = relay—motor
m = electromagnetic—selsyn
[9] See footnote 9.

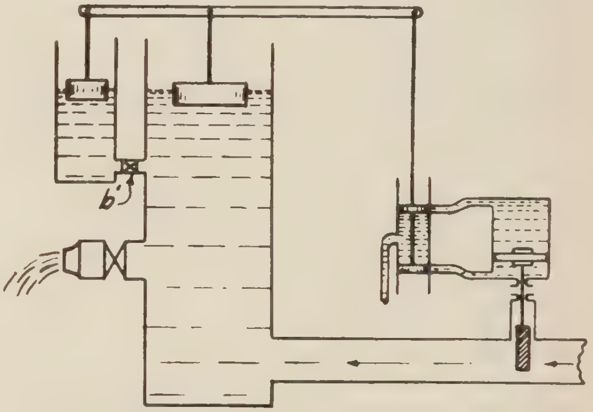


FIG. 3 CLASS XII REGULATOR FOR NONDEVIATION CORRESPONDING CONTROL

[This regulator, revised from the author's Fig. 17 now becomes another mechanical form of Class VII control.]

operated control, and yet have the apparatus at the same time able to respond to any new changes that come about during the period otherwise ineffective.

A simple way of determining the difference between the storage-lag pacer and the time-lag compensator, is to realize that the first is primarily sensitive to the rate of change. It can anticipate overshooting, shifts the phase and is capable of changing the control point so as to anticipate the condition that will come about when the changes that have been made will have had time to affect the inventory of the system. The straight time-lag compensator acts to give an overcorrection for a period of time proportional to the time lag and regardless of the amount of inventory or storage lag. Depending on conditions it frequently actually calls for less and reduces the valve opening to a smaller flow after having passed a compensating slug while the indication or meter still is on its outward excursion and calling for increasing quantities.

We have had controls where, under actual working conditions, in order to get the best results it was necessary for the control to open up a valve due to rate control, while the reading was still on the other side but approaching the control point rapidly, and while the deviation or proportional control was calling for less. Then while the latter plus the storage-lag pacer was calling for more, the time-lag compensator actually overpowered both of these control effects and called for less, so that by the end of the excursion away from the right value, and while calling for more according to the deflection, all of the regulating had been done and the various control effects neutralized one another so that on the way back to the control point practically no action was being taken. Then after some time, when the effect of all this got to the sensitive element the reading was very close to right.

With the help of this paper[1] by Mr. Smith it has been much easier to prepare Table 1 of this discussion which shows the four control effects, their various stages of perfection and interdependence, and the combinations and permutations of these various effects that are possible in any one control unit. Then if we remember that any one control unit of a whole system, in itself often requires compensation for its own storage or time lag, or both, it is very easy to see that the number of combinations is infinite. Obviously, any of these control effects can be carried out either by direct action, by pilot valves, relays, electromagnetic units, photoelectric devices, etc.

For simplicity in correlating these points, each of the various classes of controllers shown by Mr. Smith, plus the one shown in Fig. 3 of this discussion, is listed in Table 2 of this discussion with the various control effects that enter into each operation and roughly the degree of perfection of each of these.

To illustrate the development of Tables 1 and 2 of this discussion let us analyze the Class VII regulator.

Factor I. Metered control, is not shown in Fig. 12 of the paper. It does not refer to any proportioning or metering device used to keep the flow through the valve proportional to the demand independent of the level of the reservoir. This function can be added when desired. It rates zero for the control factor that is omitted.

Factor II. Deviation control is embodied in the highest and best type. Each change in level calls for a change in the setting of a pilot valve proportional to the amount of deviation regardless of the total demand, the level reading remains the same. There is no throttling range or drooping characteristic. It controls to a point, and is rated *A* under *II*. The action of the pilot valve is accumulative or integrating. The change in the position of the pilot or the sensitive element does not cause a direct and corresponding change in the control valve, but instead determines the amount of fluid that will accumulate back of the piston to move the valve to its new position. It uses a noncompressible fluid for quick, accurate, and continuous transmission of the control impulses. Hence, reference to *iplA* for Class VII regulators under factor *II* stands for an integrating pilot-operated liquid-pressure deviation control that does all it can do to keep the reading at a point regardless of the demand.

Factor III. Storage-lag pacer effect is obtained by a dashpot in which the rate of change of level reading is used, not only to get an idea of the actual change in demand which occurs, even though it is buffered by the inventory of the system, but also to overemphasize the effect of the rate of change. Overshooting of the control point is anticipated and counteracted, so that, in effect, the control operates as though the reading were at the point at which it will arrive if the constants of the system do not change in the meantime. Therefore, in Table 2 rates under *II*, *iplA*, for an integrating, pilot-operated, liquid-pressure-powered, storage-lag pacer.

Factor IV. Time-lag compensation is not embodied in Fig. 12 of the paper. There is no means shown that would make it possible to compensate for the undercorrected flow that passed before the control equipment was able to reach the new setting. This requires a control factor which will call for a change in supply in excess of the required change, for period of time partly determined by the response lag, after which the more correct value of flow is established. All this should be done within the time required for the reading to make its outward excursion. This eliminates cycling entirely.

While good engineering aims to reduce this lag to the minimum, so that the need for compensation is reduced, there generally remains enough to cause loss or inefficiency. This is particularly important with the modern tendency in engineering for less and less inventory and smaller, more responsive units.

A. F. Spitzglass.[13] Mr. Smith has mentioned the need for clarification and simplification in the field of automatic regulation. In this fast-changing art, with its ever-expanding scope and ever increasing boldness of application, development has occurred spontaneously from many independent sources. Each drew on its own background of experience. The turbogovernor designer created highly refined hydraulic mechanisms. The electrical engineer attacked the problem in terms of motors and contacts. Others drew on their experience in the gas fields and developed pneumatic operation. The theoretician thought in terms of vibration phenomena, the plant engineer in terms of his process.

Quite naturally each carried along the nomenclature of the art from which the inspiration was drawn and a baffling multiplicity of terms exists as a result. Today the trend is toward standardization and to a more composite understanding. The confusion in nomenclature, however, still extends to the conceptions and definitions and renders the task of presenting to industry a straightforward presentation well-nigh impossible.

We must therefore compliment the author for presenting for general consideration a tentative starting point. Due to the many points of view his classification will not satisfy many of his contemporaries. Even in the author's mind it is not as important that it should do so, as that it should stimulate activity toward ultimate simplification and clarification.

Individual effort is insufficient to cope with this task of standardization. The field of regulation is capable of embracing the entire range of industrial processes. Certain generalizations are possible and in an accompanying discussion by Dr. M. J. Zucrow[14] this phase of the problem is most aptly discussed. These generalizations are purely mathematical, however, and while they form the very groundwork and background of the concept of regulation, they must be complemented by analyses extending to the specific processes of industry in order to be utilized to practical advantage.

Mr. Smith has carried this program a distinct step forward with an analysis of regulator types. This analysis, while useful, will give rise to much controversy, but the very existence of this difference of opinion will emphasize the author's main point that the necessity of an authoritative effort to clarify the entire problem. Every branch of engineering is involved and the problem can only be handled by a group truly general in scope. A special A.S.M.E. Committee could accomplish much by making it possible for all those interested in controllers to use the same terminology, even though they be in widely divergent fields.

The writer has found several approaches to the problem of classification of automatic regulators. Mode of application, ultimate result, metering response, stabilizing mechanism, inherent stability, power medium utilized, and economic factors; from any of these considerations a new classification arises. Inevitably these classifications overlap and contradict each other to such an extent that we must resort to the convenient mechanism of "simplifying assumptions" in order to fit the pieces of our puzzle into the simplest pattern.

For example, it is very convenient in regulator theory to assume massless power linkages, and incompressible operating fluids. But these factors are only negligible in liquid-operated regulators, while in pneumatic devices they form an important factor and even act as a limitation to the use of air as a power medium for regulators. Therefore, any classification of regulators must be cross-classified with relation to the power medium utilized, as it is very possible that a regulator which, when actuated by an incompressible fluid will be stable for a given control operation will be unstable if actuated by a compressible gas should the speed of operation required be sufficient to create an appreciable inertia in the power linkages.

Further amplification of the author's very general statement in the abstract of the paper that "sensitivity, speed, power, stability are pertinent variables of automatic regulators" would be of great value. There is a wide divergence of opinion on the relative importance of these four factors, and it is entirely due to an attempt to consider the regulator apart from its application. Thus, there are some control applications in which it is important that the sensitivity be of a low order in order to give a simple and stable control, while in the regulation of a suction main on an open-hearth furnace pressure very high degrees of sensitivity are necessary.

Speed is another such contradictory variable since stable regulation can be obtained by increasing the speed of the regulator in cases where no metering lag exists or by decreasing it where a

[13] Vice-President, Republic Flow Meters Company, Chicago, Ill. Mem. A.S.M.E.

metering lag does exist. In the latter case the degrees in speed would cause a consequent increase in the sensitivity and accuracy of regulation.

Stability is a function of all the other elements in the regulator plus all the variable elements in the application. The Class VII regulator is shown to be stable for a very wide variety of conditions, but any specific regulator of this class must be analyzed further to answer the question: Will the regulator itself have the inherent speed, sensitivity, and power necessary to perform the cycle of operations indicated on its characteristic curve? It is not merely refinement of manufacture that the writer has in mind but actual limitation due to class of metering device or class of power medium.

Referring to the specific classification adopted by Mr. Smith, the writer's experience has been for the most part with regulators of Classes V, VI, VII, and XII.

Of these, Class V is a very common form of regulator giving "band control." Case VI can be considered a special case of Class VII, in which the reset spring of the latter is increased to the point of rigidity. Obviously, therefore, it is quite limited in application as compared to Class VII.

Again Class XII can be reproduced as a special case of Class VII in which the reset spring is weakened to such an extent that the piston must *overswing* its control point in order to compress (or tension) the spring enough to create the follow-up pressure that retards the motion of the regulator. Furthermore, Class VII with a locked dashpot becomes Class V, while with a wide-open dashpot it becomes either Class IV or Class III, depending upon the characteristic of the meter. Thus, Class VII, by virtue of its wide field of application, occupies a unique position in this classification and Mr. Smith is fully justified in treating the Class VII regulator as a basis of comparison with other classes of regulators. In the ultimate form in which the suggested report would be presented, it would be very simple to demonstrate how the Class VII can be used in the same manner as many of the other classes of regulators and this would form a logical extension of the mathematical treatment Mr. Smith has given to the subject of stability.

Concluding, it is sincerely hoped that these questions will become the subject for a disinterested study on the part of a proper A.S.M.E. committee. An authorized report on automatic regulation would give a common starting ground that is very sadly needed if we are to make the art of regulation keep pace with the demands being made upon it by industry.

M. J. Zucrow.[14] There can be no controversy over Mr. Smith's allegation that the literature pertaining to the art of regulation by electrical and mechanical devices has been outstripped by the art itself. The only qualification that might be made is that the lack one finds in the technical press of this country exists to a smaller extent in such European countries as Germany. To the writer's knowledge, the only detailed discussions of the mathematical theory underlying the coordinated regulation of several variables are those written by German engineers. That a wide dissemination of a similar literature in this country would be valuable to all parties interested in this subject cannot be doubted. Furthermore, one cannot deny that there is a lack of definition and a looseness in the current use of the terminology. This is not limited to the statements of the manufacturers' advertising departments, but is found among those of engineers. If the development of no other phase of the literature be sponsored by a special research committee of the A.S.M.E. that of standardizing and defining the terminology would be a worthy undertaking for such a body. Their recommendations will give authority to the terms finally adopted and assist materially in the development of a common language which all can understand. In this regard, Mr. Smith has made an excellent beginning by presenting a list of some of the more common terms together with their definitions. The writer is pleased to note that these definitions are merely suggestive. Definitions are fathered by the point of view of the definer. Perhaps, if they were developed from a basis founded upon an analysis of what is involved in the problem of regulating the value of a variable, to a definition of the functional parts of the mechanism, the results might have a more general applicability.[15]

[14] Republic Flow Meters Company, Chicago, Ill. Mem. A.S.M.E.

The regulation problem may be analyzed from a different, and perhaps more general, viewpoint than that adopted by the author. To illustrate this mode of analysis, the writer will discuss the general problem of a steam-pressure regulation, such as that shown schematically in Fig. 4 of this discussion. The remarks will be confined to regulators which operate with auxiliary power supply; that is, pilot-operated regulation. The problem is to maintain the pressure ahead of the demand valve B at a constant value.

The mathematical procedure involves certain simplifying assumptions. The pressure regulator is assumed to be a massless device; this is allowable because special means can be employed

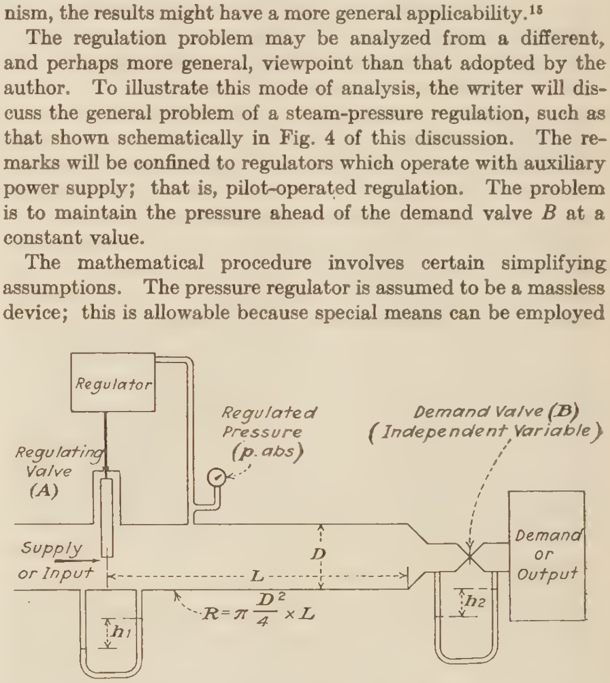


Fig. 4 Simple Pressure-Regulating System

to keep its mass and stroke small, and to operate successfully the regulator does not require any mass. In the usual case, the mass of the regulator is merely the weight of the transfer lever connecting the power cylinder to the pilot valve.

The system shown in Fig. 4 of this discussion will be at rest only when the steam demand (heat output) and steam supply (heat input) are balanced. The steam pressure which is to be maintained constant by the regulated valve is a measure of the storage of the system, and it is the duty of the steam-pressure regulation to maintain the storage at a constant value. While one can conceive of a regulation process in which a regulator element measures the demand and instantaneously positions the regulating valve to its corresponding position, so that no vibrations occur, this is not the usual case. Ordinarily the difference between the supply- and demand-steam flows acts upon the storage condition of the system, which in its turn reacts back on the regulator. The entire process involves a time lag between the change in the storage and the corrective action of the regulator, so that the regulated system passes into the new equilibrium condition with a vibration. The equation of the vibration is influenced, in general by the characteristics of the change in the demand, the particular fluid flowing in the pipe, the pressure drops h_1 and h_2 and the regulator itself. In the case presented

[15] "Regelung wärmetechnischer Grössen," Verfasser: J. Krönert, *Archiv. für Technisches Messen*, J 060-1, Reference T-109, August, 1935.

in Fig. 4 of this discussion, no specific characteristics have been assigned to either the regulator or the demand. The demand valve B may be hand-actuated or operated mechanically. The demand steam flow may be utilized in such units as a turbine, accumulator, or a steam hammer. Consequently, the changes in demand may be of a uniform character, sudden or cyclic. Its specific characteristic will have an influence on the equation for the steam demand. Only the simplest case will be discussed.

Let W_0 = the steam consumption when the system is at rest (the normal supply) at the time $t = 0$; W_{max} = the maximum quantity of steam which is controlled by the regulator; W = the steam flow at any instant t; t = any time during the period of opening (it will be assumed that the valve opening is a linear function of its movement, and is opened with uniform velocity); and T_0 = the time which would elapse before the maximum steam flow past the regulator valve would be taken up (or shut off) by operating the demand valve B. For want of a better name this time will be called the "demand period."

To illustrate the significance of the time T_0, suppose that the valve B is operated manually. The process of opening the valve might be to alternately and gradually increase the valve opening for 1 sec, and wait 1 sec to note the effect, then to repeat this process until the desired quantity of steam flows through the valve. On the other hand, the valve might be opened continuously to increase the steam flow at a uniform rate. These two cases are illustrated in Fig. 5 of this discussion, and the case shown at the right is assumed to apply to the writer's discussion. In

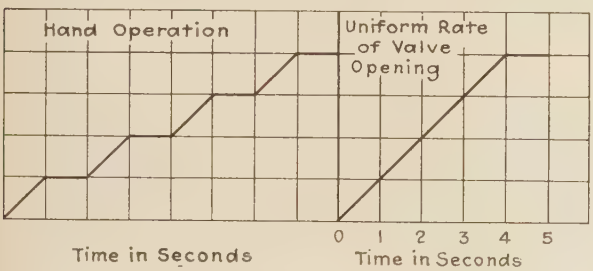


FIG. 5 DEMAND-FLOW CURVES

the latter case the steam is taken up at a uniform rate and the equation for the rate of steam flow past the regulating valve is

$$W = W_0 + \frac{t}{T_0} W_{max} \qquad [15]$$

If the steam supply has to be changed to meet a sudden demand, the equation for the steam demand would be

$$W = W_0 + xW_m \qquad [16]$$

where x is that fraction of the maximum steam flow W_m which is required with a rapidity so great that it may be termed a "sudden demand." Obviously, a steam demand defined by Equation [15] will have a different reaction on the regulation process from one defined by either Equation [16] or their combination.[5] It can be shown that in general the steam-flow equation for a uniform and sudden demand occurring simultaneously is

$$W_2 = W_0 + (t/T_0 + x)W_{max} \qquad [17]$$

Let p = the value of the absolute pressure for which the regulator is set; Δp = a deviation from p; $\phi = \Delta p/p$ = the departure from normality; $\delta = \phi_{max}$ (Δp_{max} is the pressure deviation for which the regulator has its full operating velocity); m = the position of the power piston at time t; $M = m/\phi_{max}$; and θ = ϕ/δ. Let the rate of steam flow through the regulating valve be assumed to be proportional to the valve position; that is, to the position m of the power piston. Then the maximum flow W_{max} corresponds to M_{max}, and a change in steam flow ΔW corresponds to some value of m. Let W_1 be the rate of steam flow through the regulating valve, then

$$W_1 = W_0 + MW_{max} \qquad [17a]$$

Hence, if the demand flow be less than the supply flow, then the pressure in the pipe between the valves A and B will rise; and vice versa. If the volume of this pipe is V it will require dt seconds to fill it with the unbalanced flow $W_1 - W_2 = \Delta W$. The rise in pressure causes a change in the steam density ρ amounting to $d\rho$. The storage is, therefore, increased by the weight of steam $Vd\rho$. Hence

$$(W_1 - W_2)\, dt = \Delta W\, dt = Vd\rho \qquad [18]$$

For the relatively small pressure changes involved, it may be assumed that the change in the steam density is proportional to the corresponding change in steam pressure; that is, $d\rho/\rho = dp/p$. Hence

$$\Delta W\, dt = V\rho\, d\rho/\rho = V\rho\, dp/p = R\, dp/p \qquad [19]$$

where $R = V\rho$ = the steam content of the pipe at time t.
But by definition

$$d\phi = dp/p, \text{ so that } dp = pd\phi \qquad [20]$$

Hence

$$\Delta W\, dt = Rd\phi \qquad [21]$$

Or from Equations [17a] and [18]

$$M = \frac{R}{W_{max}} \frac{d\phi}{dt} + \frac{t}{T_0} + x \qquad [22]$$

It is seen that the dimension of R/W_{max} is that of time. Physically, R/W_{max} is the time required for the maximum rate of steam flow to fill the piping annexed to the regulating valve. Let this time be called the "application lag" and be denoted by T_a. Substituting for R/W_{max} in Equation [22]

$$M = \pm T_a \frac{d\phi}{dt} + \frac{t}{T_0} + x \qquad [23]$$

Equation [23] is the equation for the pressure change; the sign preceding $T_a(d\phi/dt)$ is positive when the pressure increases, and negative when it decreases. This equation is perfectly general and is independent of any special regulator construction. It involves the "application lag" of the system, the position of the power piston, and the characteristics of the change in the steam demand. To establish the complete equation of motion for a given case of regulation, the chain of circumstances caused by a "departure from normality" must be analyzed for the specific regulator.[5]

In comparing the suitability of different regulators to any application, three phases of the regulation process are of major interest: (1) The conditions underlying a stable regulation, that is, one in which oscillations are quickly damped out. (2) The value of the maximum departure from normality which will occur with a definite change in demand. (3) The period of the regulation process; for this should not exceed a practical allowable value.

These phases can be investigated by applying Equations [24] of this discussion to the speicfic problem. Ordinarily the result will be in the form of a differential equation of the form

$$\left.\begin{array}{l} C_0 \dfrac{d^2\phi}{dt^2} + C_1 \dfrac{d\phi}{dt} + C_2\phi = 0 \\ C_0 \dfrac{d^3\phi}{dt^3} + C_1 \dfrac{d^2\phi}{dt^2} + C_2 \dfrac{d\phi}{dt} + C_3\phi = 0 \\ \cdots\cdots\cdots\cdots\cdots\cdots \\ C_0 \dfrac{d^n\phi}{dt^n} + C_1 \dfrac{d^{n-1}\phi}{dt^{n-1}} + \cdots\cdots + C_n\phi = 0 \end{array}\right\} \quad \ldots\ldots [24]$$

The relationships between the constants $C_0, C_1, \ldots\ldots C_n$ determine the stability of the regulation.[16]

Mr. Smith chose the first of Equations [24] to illustrate the vibratory characteristics of a regulation process. It might be well to amplify his remarks. The regulation equation can be written in the form

$$\frac{d^2\phi}{dt^2} + a\frac{d\phi}{dt} + b\phi = 0 \quad \ldots\ldots [25]$$

The corresponding characteristic equation, found by letting $\phi = e^{ct}$, is

$$c^2 + ac + b = 0 \quad \ldots\ldots [26]$$

The solution of the Equation [26] is

$$c = -\frac{a}{2} \pm \sqrt{\frac{a^2}{4} - b} \quad \ldots\ldots [27]$$

If $a^2/4 > b$, the radical in Equation [27] has a real value, but if $a^2/4 < b$ it has an imaginary value.[17] The latter is the case being considered; when $a^2/4 > b$ the result is aperiodic.[18] When $a^2/4 < b$ the solution of Equation [25] is

$$\phi = e^{-\frac{a}{2}t}(C_1 \sin \omega t + C_2 \cos \omega t) \quad \ldots\ldots [28]$$

where ω is the angular velocity of the cycle in radians per sec (see author's Equation [1]). The values of the constants of integration C_1 and C_2 are found from the initial conditions.

It has been shown by the author that the value of factor $e^{-\frac{a}{2}t}$ determines the degree of damping. The rate of damping depends upon the magnitude of a, and the amplitude of vibration diminishes after every cycle in the ratio[19]

$$e^{-\frac{a}{2}t} : 1$$

If the amplitude of the first half cycle is assumed to be $A_1 = 1$, then the decrease in the amplitude A_2 for the second half cycle will be a measure of the damping. The time for a one-half cycle is

$$\omega = \sqrt{b - \frac{a^2}{4}}$$

so that

$$t = \frac{\pi}{\omega} = \frac{\pi}{\sqrt{b - \frac{a^2}{4}}} \quad \ldots\ldots [29]$$

[16] "Regelung der Kraftmaschinen," by W. Tolle, third edition, Julius Springer, 1909.

[17] "Functions of a Complex Variable," by E. J. Townsend, Henry Holt and Company, New York, 1915.

[18] "Advanced Calculus," by W. Osgood, The Macmillan Company, New York, N. Y., 1922.

[19] "Vibration Problems in Engineering," by S. Timoshenko, D. Van Nostrand Company, Inc., New York, N. Y., 1928.

A_2 is the value of ϕ when $t = \dfrac{\pi}{\sqrt{b - \frac{a^2}{4}}}$

$$A_2 = e^{-\frac{\pi}{\sqrt{\frac{4b}{a^2} - 1}}} \quad \ldots\ldots [30]$$

From Equation [30] of this discussion it is seen that the magnitude of A_2 depends upon the ratio $k = a/2\sqrt{b}$. The per cent reduction in amplitude for the one-half cycle is

$$P_A = 100\left(\frac{A_1 - A_2}{A_1}\right) = 100\,(1 - A_2) \quad \ldots\ldots [31]$$

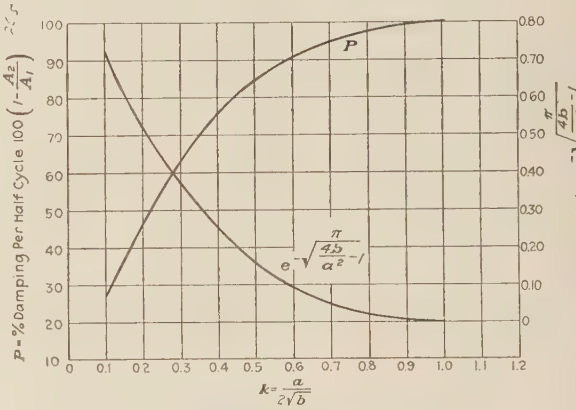


Fig. 6 Damping and Amplitude Curves

Now a and b in the criterion $k = a/2\sqrt{b}$ have the following significance. If b be considered to be the damping required for an aperiodic regulation (condition if $a^2/4 > b$) and a the actual damping, then k is the ratio of the actual damping to the aperiodic damping. This means for the vibration decay to be rapid, the value of k must be large. Fig. 6 of this discussion illustrates P_A and A_2 as functions of k.

Now the damping of a regulation may arise in the more usual cases from three sources:[20] (*I*) Inherent damping of the system itself. (*II*) Damping due to the flow of fluid through the pipe producing a pressure drop between the measuring station and the demand valve. (*III*) Damping due to a mechanical follow-up. These three types of damping depend on δ, T_a and T_s; where T_s is the regulator period, that is, the time required to move the piston its full stroke with the pilot valve wide open. Now δ is related to the sensitivity of the regulator and $1/T_s$ is the regulator speed. Furthermore (*I*) and (*II*) depend upon the load factor $z = W/W_{max}$. The specific equations for $k = a/2\sqrt{b}$ for (*I*), (*II*), and (*III*) are, however, different. They have the following forms

$$k_a \propto z\sqrt{\left(\delta\frac{T_s}{T_a}\right)} \quad \ldots\ldots [31a]$$

$$k_b \propto z\sqrt{\left(\frac{T_a}{\delta T_s}\right)} \quad \ldots\ldots [31b]$$

$$k_c \propto \sqrt{\left(\frac{T_a}{\delta T_s}\right)} \quad \ldots\ldots [31c]$$

Since k must be large, about 0.5 at least, to give stability, it is seen that the damping effects (*I*) and (*II*) are inconsequential for

[20] "Regler für Druck und Menge," by G. Wünsch, R. Oldenbourg, Münich, Germany, 1930.

small load factors, or if T_a is large. Since the damping due to a mechanical follow-up is independent of the load, it is apparent that regulators without such a follow-up must be restricted in their application.

Mr. Smith has pointed out that power, speed, sensitivity, and stability are the requirements for good regulation. That the regulator must have ample power to overcome the resistances it is to encounter needs no further comment; it is a consideration, however, in applying direct-operating regulators. The remaining requirements are not independent of each other as an examination of Equations [31] of this discussion quickly reveals.

The classification of regulators presented by Mr. Smith is interesting and instructive. There is no doubt in the writer's mind that some organization of the knowledge regarding the construction and behavior of regulators, whether by classifying the devices as the author has done or from some different viewpoint, would be valuable to all who are interested in this art. Any scheme which brings out clearly the behavior of the different types of devices with emphasis upon their suitability for different applications together with their limitations should be welcome. A regulation problem has to be engineered, and any information which will assist the customer in determining exactly what he will be getting if he purchases one device or another will be of value to all.

S. D. Mitereff.[21] The writer is under the impression that while the paper of Mr. Smith is valuable in many respects, it does very little to clarify the problem of automatic control in its basic aspects. It might be helpful, therefore, to present the fundamental situation from an angle which will permit a better visualization of factors involved.

A control installation consisting of inflow, outflow, and storage can be represented by a dynamically equivalent layout shown in Fig. 7 of this discussion. This layout consists of a massless carriage M disturbed by a random force F_x, damped by the dashpot O and stabilized by the restoring force F_s. Designating the deviation of the center line C—C of the carriage from datum line X—X as P, the motion of the carriage is expressed by the equation

$$F_s + k_2 \frac{dP}{dT} = -F_x \qquad [32]$$

The term $k_2(dP/dT)$ is due to operation of the dashpot O which produces a force proportional to the rate of motion of the carriage.

Equation [32] of this discussion expresses also the variation in the amount of fluid or power in storage if we call F_x the rate of flow (uncontrollable); F_s the rate of flow (controllable); P the amount of fluid or power in storage; and k_2 the constant depending upon the storage capacity of the receptacle (fly-wheel effect in case of turbine, for instance).

The relationship between P and F_s can be selected at will, depending as it does, upon the characteristic of the regulator. It is quite adequate to make $F_s = k_1P$ since the resulting equation of deviation is perfectly aperiodic, that is

$$k_1P + k_2 \frac{dP}{dT} = -F_x \qquad [33]$$

This equation expresses the motion of a massless carriage M if stabilized by dashpot O and a tension-compression spring S.

If, however, we make $F_s = k_1\int PdT$, the resulting equation of deviation (after differentiation) is

$$k_1P + k_2 \frac{d^2P}{dT^2} = -F_x' \qquad [34]$$

[21] Y.M.C.A., Petersburg, Va.

where $F_x' = \frac{dF_x}{dT}$, which is another random disturbing force.

The motion represented by Equation [34] is oscillatory, since it pertains to a carriage M having a mass and stabilized only by a tension-compression spring S.

Since in some instances it is advantageous to control "to a point" and therefore to retain the term $k_1\int PdT$ in the regulator characteristic, the writer proposes in such cases the characteristic

$$F_s = k_1 \int PdT + k_3P - k_2 \frac{dP}{dT} \qquad [35]$$

When this value of F_s is substituted in Equation [32] the resulting equation of deviation P is (after differentiation) again aperiodic, or

$$k_1P + k_3 \frac{dP}{dT} = -F_x' \qquad [36]$$

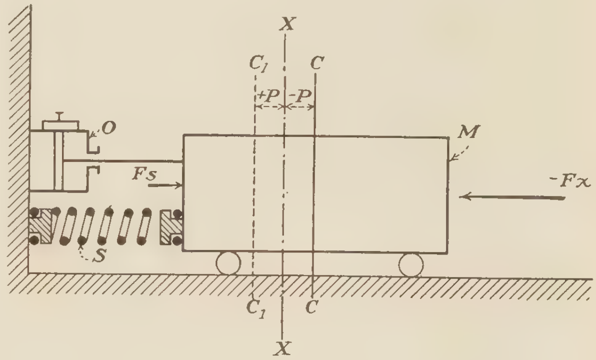


Fig. 7

An interesting additional fact is that the natural damping effect of the storage (value of k_2) can be either increased or decreased by respectively adding or subtracting the term $k_5(dP/dT)$ from the normal characteristic of the regulator. This expedient may be used to advantage in central power-station practice in order to better divide the load fluctuations between several turbines, thus minimizing the surges of current in a transmission line connecting two systems of unequal fly-wheel effect.

A different class of automatic-control problems is represented by automatic steering and stabilization. The class is represented much more literally by Fig. 7 of this discussion, since in this case we have a mass M damped by the natural damping effect O of the surrounding medium and stabilized by a natural restoring force such as of the spring S as well as by the artificial restoring force F_s, against the disturbing random force F_x.

The equation of motion of the object to be stabilized is

$$F_s \pm k_1P + k_2 \frac{dP}{dT} + k_3 \frac{d^2P}{dT^2} = -F_x \qquad [37]$$

It should be pointed out that the natural restoring force k_1P may be either negative (monorail cars) or absent (steering, of ships). The natural damping factor $k_2(dP/dT)$ is always positive, but may be absent (monorail cars). The reaction of the mass $k_3(d^2P/dT^2)$ is always present and is always positive.

The artificial restoring and stabilizing force F_s is produced by the action of a rudder or ailerons in case of steering of ships and aircraft precession of gyroscope, shifting of weights and movement of stabilizing fins in case of monorail cars and antirolling ship installations.

It is apparent that to make the motion expressed by the Equa-

tion [37] of this discussion stable and aperiodic, it is sufficient to make

$$F_s = k_4 P - k_3 \frac{d^2P}{dT^2} \qquad [38]$$

The resulting motion is expressed by an equation of the type of Equation [33] of this discussion, provided there exists a natural damping factor of sufficient magnitude.

To take care, however, of either negligible, absent, or excessive natural damping factor it is necessary to make

$$F_s = k_4 P \pm k_5 \frac{dP}{dT} - k_3 \frac{d^2P}{dT^2} \qquad [39]$$

The simplest device for obtaining the angular-acceleration term $-k_3(d^2P/dT^2)$ consists of a balance (pendulum of infinitely great radius) restrained from rotation by either a compression rheostat or by a fluid-pressure multiplier (cup-bleeder valve).

From the foregoing discussion an interesting question arises as to the proper method of automobile ride stabilization. It seems to be practical to stabilize a high-speed car by installing small stabilizing airfoil sections above each wheel, somewhat in the nature of present fenders, and to change the angle of attack of each airfoil by means of a regulator with the characteristic expressed by Equation [39]. It will be close enough for the purpose to obtain the first two terms of the Equation [39] through successive integration (electric or hydraulic) of the term $-k_3(d^2P/dT^2)$ which, of course, can be obtained easily from the inertia effect of a weight.

Another theoretically correct method of automobile ride stabilization consists of applying an artificial stabilizing force

$$F = k_1P + k_2 \frac{dP}{dT} - k_3 \frac{d^2P}{dT^2} \qquad [40]$$

(where P is the vertical displacement of car frame obtained in practice by integration of vertical acceleration d^2P/dT^2) between each corner of car frame and the axle. Such force can be generated either by a piston-cylinder or core-solenoid combination connecting frame and axle in parallel with the usual spring.

This arrangement would, of course, require an external source of hydraulic, pneumatic, or electric power for its operation, and it constitutes therefore the activated shock absorber in distinction from self-operated shock absorbers of previous designs.

A very similar and so far neglected problem is encountered in stabilization of an airplane as a whole in a vertical direction to prevent airsickness among passengers from "bumps" caused by vertical air currents. This problem can be solved by actuation of such wing-lift changing devices as flaps or slots by an automatic control responsive to the changing inertia forces acting upon a small pilot weight (U. S. Patent No. 2,015,862). Since in this case a vertical acceleration (deceleration) primarily is to be minimized, the vertical displacement being of secondary importance, a stabilizing change of lift $F = k_1 d^2P/dT^2$, equivalent to increase of plane's mass will be sufficient. However, characteristic

$$F = k_1P + k_2 \frac{dP}{dT} \pm k_3 \frac{d^2P}{dT}$$

can also be used in this case.

A problem closely related to that of automatic stabilization is presented by a radio loudspeaker, and microphone.

As before, the equation of motion of the diaphragm is

$$k_1P + k_2 \frac{dP}{dT} + k_3 \frac{d^2P}{dT^2} = -F_x \qquad [41]$$

where P = distance traversed by diaphragm, and F_x = force of electric coil or of sound wave actuating the diaphragm. Since F_x closely corresponds in shape and amplitude to original sound, it is desirable to obtain the relationship $k_1P = -F_x$.

Two methods are available to achieve this. It is possible to modify original radio impulses at the station or in the receiver to obtain the equation

$$k_1P + k_2 \frac{dP}{dT} + k_3 \frac{d^2P}{dT^2} = -F_x - k_4 \frac{dF_x}{dT} - k_5 \frac{d^2F_x}{dT^2} \qquad [42]$$

This equation is reduced by proper selection of constants k_4 and k_5 to $k_6P = -F_x$.

The second method consists of obtaining terms $-k_2(dP/dT)$ and $-k_3(d^2P/dT^2)$ from the motion of the diaphragm (by means of a small solenoid, for instance, and appropriate vacuum-tube circuit) and by impressing these terms (as a force) on the diaphragm in addition to force F_x, obtaining

$$k_1P + k_2 \frac{dP}{dT} + k_3 \frac{d^2P}{dT^2} = -F_x + k_2 \frac{dP}{dT} + k_3 \frac{d^2P}{dT^2} \qquad [43]$$

The cancellation of like terms gives us again the desired equation

$$k_1 P = -F_x \qquad [44]$$

J. C. Downing.[22] After reading Mr. Smith's paper, as well as the paper by S. D. Mitereff,[3] and the discussion[23] of the latter paper, the writer finds that we are all talking about the same subject but thinking and expressing ourselves ambiguously. Therefore, the writer agrees with the author's suggestion of having a committee sponsored by the A.S.M.E. to standardize on automatic-control terminology and classification.

Since every definition we might apply to control installations and their component parts can be stated in many different ways, some group should decide upon a terminology which will be universally accepted. The writer believes we must begin at the very beginning of the subject and arrive at the basic fundamentals and definitions before we can proceed to establish such a universal terminology. Therefore, the writer presents in this discussion his conception of what the problem is, and refers to definitions by the author which, incidentally, do not agree with those used by the writer.

Our starting point must be with the subject. Our subject can be nothing but automatic control or automatic regulation. It isn't "hand" control or "manual" control but automatic, that is, self-adjusting, or not depending on the will of man. The terms control and regulation are synonomous. This can be modified to a specific type of control by the addition of the variable controlled such as automatic temperature control or automatic level control.

We can now apply this subject of automatic control and our result is an automatic-control system. This system is a self-sustaining unit. Each part of this system relies upon the other; remove any one part and you destroy the system thereby losing the title of "automatic control." The writer can conceive of an automatic-control system which is altered to such an extent that it is still a control system but has been reduced to a different class such as a remote-control system or hand-control system.

Since we have set up an automatic-control system we can now proceed to divide it into its component parts. But, before we do that, there is one more general item to be considered and that

[22] Engineer, Automatic Combustion Control, Huntley Station, Niagara Hudson Power Corporation, Buffalo, N. Y. Mem. A.S.M.E.

[23] Discussion of paper "Principles Underlying the Rational Solution of Automatic-Control Regulators," by S. D. Mitereff, Trans. A.S.M.E., vol. 28, January, 1936, p. 55.

is the purpose or function of the control system. Naturally there must be one or more variables to be controlled within the system. These variables are factors, qualities, or conditions, the values of which must be maintained within some predetermined limits by the automatic control. Since we bring in one or more variables to be controlled we must elaborate still further on our control system to make a distinction between a system with one variable and a system with two or more variables. We can class a system having one variable as a single-element automatic-control system, and one with two variables a double-element automatic-control system. This subdivision is necessary as we might speak of an automatic level control which is a single-element, a double-element, or a triple-element class, i.e., one considering the level only, the level and flow, and the level and two flows, respectively.

Getting back to the segregation of the automatic-control system, there are three major parts: (1) The variable detector, (2) the controlling means, (3) the controller.

Part (1) has been referred to as the measuring device, impulse-receiving element, and variable responsive meter by various writers. Part (1) is the heart of the control, it is the master and the writer believes a term such as "variable detector" is a good general title. The writer cannot agree with the use of the term "meter" as his conception of the word is "to measure." All instruments are in a true sense meters but the writer's classification has been such that a meter is that type of instrument which integrates, records, or indicates the flow of fluid. The writer will grant that a meter may be used as a detector, but so may a temperature-recording element, or a pressure-recording element. The term "meter" is not general enough and is misleading. The author refers to a float and reservoir as a meter which, in the writer's opinion, should be referred to as a pressure- or level-indicating element.

Part (2) can be expressed in various other ways as long as it is known that it is the connecting method between the detector and the controller.

Part (3) is the controller or regulator which is the device used to control the variable.

Again, the author uses the term "automatic regulator," where the writer would use "automatic control system," and in using the term the author refers to the hunting of the automatic regulator, but apparently means to say the hunting action of the variable as produced by the automatic-control system. The writer does not believe that you can take any one part of the system and refer to its classification or characteristic without considering the whole system. Instead of referring to classes of regulators, the writer would speak of classes of control systems.

The writer is of the opinion that it would be well to include a definition of the value of the variable which the control system is set to maintain. This has been referred to as the "set value" and the "control point" in the author's definitions of "reset" and "damping decrement," respectively.

C. O. Fairchild.[24] Process engineers will undoubtedly welcome the author's implied proposal that the A.S.M.E. should sponsor the development of this subject and plan the preparation of compact treatises for the use of those not familiar with it. This paper is an admirable beginning. It is certainly the most successful effort to date, to classify automatic regulators, and develop terminology. The writer disagrees with the author at many points but most of these cannot be cleared up unless the subject breaks into print with full force and the sustained support of an active group.

It is quite natural that a mechanical engineer and a physicist acting in different fields should disagree, not only on the use of terms, but in the method of approaching the subject. A reasonably concise discussion of these different points of view would require another paper as long as the author's but the writer would like to give a few examples, with the purpose of cautioning mechanical engineers against drawing too many general conclusions from hydraulic or mechanical examples, and against the habit of depending too much upon a mechanical setup instead of upon a physical principle. Sir James Jeans, in the preface to his "Theoretical Mechanics" writes " . . . I believe that all students of mechanics, no matter what their aims and intentions may be, will be in the same position in one respect, namely, that they will best begin the study of the subject by trying to acquire a firm grasp of the physical principles, leaving aside at first all mathematical developments and all practical applications, except in so far as these contribute to the elucidation of the fundamental principles."

The question is raised: Which is the better method of approach to this subject, the elucidation of the fundamental principles, or the classification of types of instruments and study of their characteristics? Another possible method is to classify according to the type of application or the kind of variable to be controlled. For example, the study of level control teaches only part of the subject of temperature control, in which the principal complication is the attenuation of temperature between the controller and meter, when heat is conveyed by solid conduction. In fact, temperature control is sometimes sufficiently involved that the study of one case becomes very tedious. Nevertheless, many fundamental principles can be recognized as generally applicable.

In one sense it is not proper to use level control as typical. It is a special case of indirect control in which, in the absence of meter response lag or pure time lag, there is always a phase difference of 90 deg between the controller and meter. Thus, capacity lag alone cannot produce hunting. Physically this is identical with an electrical circuit having capacity but no inductance; one in which oscillation cannot persist. Of course, the author's use of level control is legitimate, other sources of lag being always included. In such cases it should be pointed out that during relatively slow oscillations or hunting, the phase difference is almost exactly 180 deg.

The writer does not fully agree with the author's handling of "follow-up," "reset means," and "storage-lag pacer," and the extensive use of Class VII regulator as typical. We would add a class similar to VI in which the piston and cylinder of the dashpot are connected with a spring, and make VII a subclass. We would also differentiate between true automatic reset and pseudo-reset of this added class, for which many manufacturers claim reset. We are not concerned here with the use of "reset" as a term, but with the theoretical treatment of "resetting."

The writer prefers the term "constrained" in place of "corresponding" for reasons requiring some discussion.

The writer wishes to emphasize his opinion that the author's expressed purpose deserves the hearty support of the Society without particular attention to technical criticism of the paper under discussion.

John I. Yellott.[25] The rapid increase in recent years in the number of types of controllers has unfortunately not been accompanied by a corresponding increase in the amount of literature available. Consequently, the mastery of this art is difficult for those who have not grown up with it.

The writer is of the opinion that a treatment of the subject, sponsored by the A.S.M.E. in a manner similar to the fluid-meter reports, would be of great value. Publication of such

[24] Director of Research, C. J. Tagliabue Manufacturing Company, Brooklyn, N. Y.

[25] Assistant Professor of Mechanical Engineering, Stevens Institute of Technology, Hoboken, N. J. Jun. A.S.M.E.

reports would perform the double function of standardizing the terminology of the art, and of supplying an authoritative reference to those who seek entrance to this very interesting field.

Although Mr. Smith specifically disclaims any desire to offer for universal adoption the terminology used in the paper, nevertheless it seems likely that the terms which he has used will stick. It seems proper, therefore, to question a few of them.

The expression "throttling range" is open to the objection that, for most engineers, "throttling" has a specific meaning which does not coincide with the sense in which it is used in this expression. Would not "operating range" or perhaps "functioning range" be better in that they would not be as liable to misinterpretation?

The term "speed of controlling" is also subject to criticism in that "speed" should have the length and time as dimensions. May not "speed" be replaced by some word, such as "period," which refers only to time? Where ambiguity is possible, is it not preferable to coin a new expression? It is certainly better to be entirely ignorant of the meaning of an expression than to have half an idea which is probably wrong.

Mr. Smith should be congratulated on the presentation of such an instructive paper. It is to be hoped that this will be the forerunner of a number of contributions on this important subject.

J. L. Kimball.[26] The follow-up system of compensation in regulators of the class discussed in the paper has for the last few years, gradually lost favor for two reasons. First, it results in a comparatively wide operating range, and second, it does not anticipate time lag.

It is generally conceded that time lag is the main cause of objectionable oscillations known in the art as "hunting," and while the follow-up arrangement is effective in preventing an overtravel it is not so effective in preventing a reversal of operation when marked time lag is present. The more advanced thought is to dissipate the follow-up effect in time with the dissipation of the time lag accomplished by means of a self-restoring dashpot arrangement such as shown in Fig. 1 of the paper.

The conventional follow-up such as shown in Fig. 10 of the paper results in a wide operating range due to gradient effect of diaphragm and springs meaning low pressure on high volume demand which is obviously the wrong way around as what is needed is an increase in pressure on increase in volume to compensate for increased pipe-line losses.

There are some makes of regulators on the market in which the operation of the servo motor automatically changes the pressure setting of the pressure-responsive device. But this is manifestly wrong adjustment and results, because of time lag, in two forces acting on the pressure-responsive device in the same direction and tending to an unstable operation.

For example assuming an upward movement of a plunger to close off a steam valve because the reduced pressure was slightly too high, and to prevent the plunger from overtraveling we automatically slide a weight out on the pressure beam, or tighten a spring under the beam. Now by this upward movement of the plunger and the slight closing of the steam valve, we are soon to have a reduction of pressure, but we had already increased the pressure setting of the regulator, so the loss in pressure and the increase in pressure setting are forces acting in the same direction and result in unstable operation.

The writer has been quite successful in his experiments in changing the pressure setting in the exact opposite direction to this, namely, in the same direction as the initial movement, thus anticipating time lag; at the same time stabilizing the regulator by means of the self-restoring dashpot arrangement as shown in Fig. 1 of the paper. The writer usually refers to this method as the "self-centering-self restoring" principle, as it results in stable operation at zero range.

[26] Mechanical Engineer, Ruggles-Klingemann Manufacturing Company, Salem, Mass. Mem. A.S.M.E.

W. A. Carter.[27] This paper should be welcomed by both the manufacturers and the users of automatic regulators inasmuch as it sets forth so comprehensively the principles involved in their design and use. It is hoped that the Society will form a committee of interested engineers to cover the subject more completely, as the author suggests.

The only detailed comments that the writer has to offer are: (1) In addition to regulators for the control of flow rate, level, pressure, temperature, and speed, it probably will be necessary to cover certain combinations of these. (2) Besides motive powers such as mechanical, hydraulic, electrical, and thermal, as mentioned it might be desirable to include a pneumatic class in order to distinguish between expansible and nonexpansible fluids.

R. P. Lowe.[28] From the sales-engineering standpoint, the writer believes that it is desirable at this time to encourage the establishment of a committee for standardizing the terminology and symbols for industrial instruments and regulators. The writer has attended several A.P.I. meetings, at one of which the use of certain industrial instruments was discussed by two manufacturers' representatives for the benefit of engineers and attendants. The terms used by these speakers differed to such an extent that, although the problem under discussion dealt with the simple control of level, the audience was confused. Furthermore, the ensuing argument between the speakers indicated that they evidently misunderstood each other.

The writer has spent over ten years in the design and construction of engineering works, which industry, in contrast to the manufacturing of controllers or regulators, has standardized its terminology and symbols so that one engineer can readily read the plans and understand the calculations and language of any other engineer in this field.

Engineering development in any field is hampered unless there can be a meeting of the minds of all concerned in that development. We know from experience that it takes the collaboration of a large number of individuals in any field to produce advances similar to those made by the radio, motion-picture and automobile industries. The uniformity of the drawings, which the author has used to illustrate various control characteristics, makes their differences comparatively easy to recognize. These graphic illustrations of operation serve as a shorthand means of visualizing the action of the various parts under operating conditions. It is believed that still further work along the line of illustration would aid those whose daily problem is the design, selection, and maintenance of such apparatus.

Although Mr. Smith has stated that his paper is of an elementary nature, the writer believes that it is introductory to more involved papers such as those of Mitereff.[3]

The writer particularly appreciates Mr. Smith's efforts to simplify a subject which has, until now, been generally presented in more complex and perplexing forms. The paper is, apparently, open minded and intended to invite discussion which will help to bridge the gap which at present exists between the designing engineer, sales engineer, and operator. The writer knows, from his association with the author, that Mr. Smith has incidentally used one terminology in his paper without seeking its adoption; instead, he seeks only to assist in starting an A.S.M.E. program

[27] Technical Engineer of Power Plants, Detroit Edison Company, Detroit, Mich. Mem. A.S.M.E.

[28] Sales Engineer, Builders Iron Foundry, Providence, R. I.

that will be useful to those interested in industrial instruments, including regulators.

Victor Wichum.[29] The author, in presenting the result of his analysis of the theory and application of automatic regulators, has performed a most useful service. His paper should be the forerunner of many others to follow, if industry is to get any appreciable value out of the latest developments of the instrument manufacturer.

The process engineer knows his apparatus and its characteristics and in selecting the proper type of control equipment, he is interested in knowing how "apparatus lag," for example, will affect the functioning of the temperature controller. Will it be necessary to purchase a controller with a special feature incorporated, in order to eliminate hunting, drifting, and resetting?

T. R. Olive, associate editor of *Chemical and Metallurgical Engineering* and secretary A.S.M.E. Process Industries Division, has clarified the importance of instrumentation in the process industries to his readers. He emphasizes that the great progress of these industries has been made possible through the successful cooperation of the process engineer with his knowledge of the chemical and physical principles of the plant process and the instrument manufacturer with his correct design of equipment for automatic control.

Messrs. Olive and Béhar[11] have classified industrial instruments and described and illustrated the many types available. They have made a worth-while contribution to the subject of instrumentation. The engineer in the process industry has been provided with a good foundation upon which to build his structure. He has his unit operations, his unit processes, and his flow sheets of process industries.

He should be taken several steps further. He should have access to a reliable source of information for choosing the particular type of controller which will serve his particular apparatus. For example, in the petroleum industry, should the top tower temperature controller be of the potentiometer type with a motorized valve or should it be a recorder controller with a fully compensated mercury-tube system and actuate a diaphragm valve with compressed air? What are the advantages of each type? All the large manufacturers of industrial instruments can furnish both types. The choice should rest with the user. There are process engineers who could make a recommendation based on experience. Why should not this information be disseminated? These engineers have offered to serve on an instrument committee which would make available this most valuable analysis of instrument application.

The large number of members of the A.S.M.E. who, in a recent survey, have shown their interest in the Process Industries Division, strongly indicates the desire for an industrial instrument committee. Since the process industries are so definitely "instrument-minded," why should not this second largest group in the A.S.M.E. enjoy the benefits to be derived from the continuation of this work?

H. A. Rolnick.[30] So few papers have appeared on automatic control that a great deal of confusion in nomenclature and ideas has resulted. This paper written from both the theoretical and practical points of view should help in stimulating discussion which will clarify the automatic-control problem.

L. M. K. Boelter.[31] The writer calls to the author's attention references which may be of value to the subject under discussion. These references books are by Wünsch and Rühle,[32] and Wünsch.[20]

Author's Closure

In preparing this closure, the author does not find time enough available to enable him to do justice to the extensive discussion of his paper, particularly for the digesting of the foreign references. He wishes to thank those who contributed written discussion and also those who attended the Semi-Annual Meeting of the A.S.M.E. at Dallas, Texas, where the paper was read, for their support of further activity on this subject by an interested group. Such a group met informally at the Annual Meeting held in New York last December and, after expressing their immediate interest in terminology, agreed upon the desirability of continuing as a subcommittee of the Process Industries Division and of holding a conference at the coming Semi-Annual Meeting of the A.S.M.E. to be held in Detroit, Mich. In the meantime, further papers on this subject and further remarks on terminology are invited for consideration at this meeting.

Some of the discussers apparently disregarded the intended scope of the paper: A tentative and incomplete "layout" to encourage an A.S.M.E. group to agree upon an authoritative and more nearly complete report, possibly along the general lines of the present paper. It seems desirable that such a report, following the example of those prepared by the A.S.M.E. Fluid Meters Research Committee, include material under three parts: (I) Instruments and regulators, per se; (II) regulator systems; and (III) factors affecting the selection and installation of one class or another of regulators for a given purpose, or process.

On the whole, the author restricted the material in his paper to part I, although agreeing on the necessity for parts II and III for a complete treatment; part III being particularly desired by members of the Process Industries Division, as indicated in the discussion by Chairman Wichum who sponsored the present paper.

The author agrees with his discussers that the material in part II is required for a general statement of the theory of regulation and submits that the discussions of Smith and Zucrow have partially supplied this complemental material. The author defends the restricted scope of the present paper as effectively highlighting the regulator elements and their definitions as a preliminary step for the understanding of complete regulated systems in part II. This was necessary for the introduction to this art of any one unfamiliar with regulators, and to facilitate the understanding of subsequent and more advanced papers.

Such a paper is an important work on turbine regulation[33] which follows the same general method used in the author's paper, that is, analyzing the mechanical system to establish the pertinent differential equations and determining, from their solutions, the stability of the system with given regulator and system constants. It is apparent that the teachings of this paper in a field other than that of industrial regulation, should be readily applicable to this latter field. For this end, it is desirable to have a common terminology throughout the various fields of regulation, which terminology can be attained only by adherence, in technical publications, to the use of good English and the sacrifice therein of vernacular expressions (trade jargon) peculiar to the various fields.

Taking the discussions in the order, as far as conveniently possible, of publication, McMahon's discussion, like the author's

[29] Chief Engineer, Sales Engineering Department, C. J. Tagliabue Manufacturing Company, Brooklyn, N. Y. Mem. A.S.M.E.

[30] Physicist, Brown Instrument Company, Philadelphia, Pa.

[31] Professor of Mechanical Engineering, University of California, Berkeley, Calif. Mem. A.S.M.E.

[32] "Massgeräte im industriebetrieb," by G. Wünsch and H. Rühle, Buchhandlung der technik, Goerg Hentschel, Berlin, 1936.

[33] "Superposed-Turbine Regulation Problem," by A. F. Schwendner and A. A. Luoma, Trans. A.S.M.E., vol. 58, November, 1936, paper FSP-58-8, p. 615.

discussion[34] of Mitereff's paper, begins by recognizing the difficulties of transition from an art to a science. Most other points that McMahon brings up as new are to be found in the present paper. He is mistaken when he states that the paper lists four desirable qualities of an automatic regulator. Actually the paper states merely that the four points are pertinent, thus avoiding any figure of merit in its presentation. McMahon is unjustified in questioning the consistency of the author's use of "sensitivity" in the paper; it has been used throughout as defined conversely by the "insensitivity" (or "dead zone"). Also, it was intended that exponent α clearly define the stability, the equations being solved either for the controlled variable or the controlling means.

It is hoped that this paper will assist in organizing those interested in this subject to permit united progress. Of course, points remain that require settling by group discussion. The author suggests that the committee encourage papers to openly present differing views and, following them, to sanction the publication of an A.S.M.E. report containing material agreed upon by the committee.

Without attempting to answer G. W. Smith's discussion in detail, it seems to the author that much of this falls under his proposed part II, especially the material on self-regulation. Although material of similar scope had been prepared by the author and E. R. Loud[35] working together, the author deleted it to restrict this paper more nearly to part I, i.e., introductory material for regulators per se. The Smith discussion helpfully refers to the work of Stein.[5] It may be remarked pertinently here that generally it is desirable to be acquainted with more than one source. The author urges that Smith, working with discussers Spitzglass and Zucrow, rewrite portions of their present discussions as a paper laying a basis for discussion leading toward part II, that is theory of regulated systems. These men can do an excellent job of bridging the present lingual gap in this art, as they show a fortunate combination of facilities in German, higher mathematics, and regulation.

It might be assumed from the discussions of Smith and Mitereff that the practical solution of an actual regulation problem is completed as soon as a differential equation has been set up. That this is not a fair assumption may appear from the Fairchild[24] quotation from Jeans, as well as from the following quotation from Trinks:

"Creative practice pays no attention to these equations, because they are too complicated. It takes much longer to master and apply them than it takes to build a governor and try it. Besides, the practically important features can be ascertained much more easily from the limiting case. (Steady hunting.) In spite of this condition, no apology is offered for the introduction of this brief sketch of the theory, because no one can ever appreciate the great usefulness of the simple equations of the limiting case unless he has wrestled for days, or even for weeks, with the solution of the complete equation. In the advanced volume a few examples of the complete calculation will be given for the benefit of those who wish to make the governing of prime movers a life study."

The tone of the Smith discussion makes it necessary for the author to point out that the paper as finally printed contained only one actual error or mistake. This was the omission, in Fig. 17 for the Class XII regulator, of the pilot valve called for by its context. Other and particular points raised by the Smith discussion are answered as follows: (1) As to self-regulation, it is commercially satisfactory to so design industrial regulators that the control valve carries the full burden of controlling resistance without benefit of self-regulation since any actual installation will generally have the benefit of some self-regulation in its system. (2) The context for Classes III and IV seems to the author to make unnecessary the corresponding portion of this discussion. The curves showing the valve travel for such regulators are proper with piston-type pilots with gradually closing ports as the control point is approached. It is also true that these curves tend to become saw-toothed in shape with electrically operated switches in place of these pilot valves. Reconsideration of the author's equations with these points in mind will show that they are correct, but that the curves may well be revised so as to appear more nearly saw-toothed in shape. These curves were stated in their introductory context as being cursory. (3) While regulation may seem very confusing from a purely mathematical viewpoint, in this connection refer to the clear physical analysis of Classes III, IV, V, VI, VII, and XII in the Spitzglass discussion. For instance, one questions that the devices shown in Fig. 3 of the paper and Class IV have equations with corresponding terms differing only in constants and not in order, since it has been established in practice that the regulator of Fig. 3 will stably control flow subject to much livelier disturbances than will the Class IV regulator. (4) As to the effect of regulator friction on hunting and the dead zone, evidently Mr. Smith has failed to consider adequately the work of Ivanoff[36] and also the common experience of those who have prevented the hammering of a water-closet valve by simply adding enough friction to absorb the kinetic energy of the unitary float valve and connecting lever arm (and the inertia effect of the water in the supply to the valve). In conclusion, none of the foregoing remarks are to be construed as minimizing the considerable value of the Smith discussion.

Grebe's discussion presents an extension of the author's classification, and attempts to apply a quantitative value to each of the classes, a matter that the author cannot comment upon inasmuch as it is one which would require open discussion. It also includes a revision of the author's Fig. 17 for a Class XII regulator that agrees with the text, the author's intent and his original sketch, which was departed from in the final preparation in an effort to improve the form but without adequate checking. It may be noted that this is a classical error, see the work of Hodgson and Robinson[37] in which in Fig. 14, page 37 the relay valve works the wrong way. This reference gives an otherwise clear treatment of regulators commonly used in steam power plants.

The Spitzglass discussion emphasizes the principal difference between the various classes of regulators in practice, that is, the speed with which they can stably operate their control valves. It should be brought out here that a Class XII regulator can compensate for lag in the regulator itself sooner, and hence better than can a Class VII regulator. However, a regulator having its meter divided as in the Class XII regulator but otherwise as in Class VII would not seem to the author to produce any unanticipated results in the present advanced state of the art.

As earlier noted, Zucrow's discussion presents complemental material in part. Zucrow's Equations [24] to [31], inclusive, seem to the author to duplicate his treatment substantially except that they are for steam instead of water, and are based on the

[34] Discussion by Ed S. Smith, Jr., of "Principles Underlying the Rational Solution of Automatic-Control Problems," by S. D. Mitereff, Trans. A.S.M.E., vol. 58, January, 1936, p. 57.

[35] Engineering Department, Builders Iron Foundry, Providence, R. I. The author is now hydraulic engineer with the C. J. Tagliabue Manufacturing Co., Brooklyn, N. Y.

[36] "Theoretical Foundations of the Automatic Regulation of Temperature," by A. Ivanoff, *Journal of the Institute of Fuel*, vol. 7, 1933–1934, pp. 118–134.

[37] "The Development of Automatic Combustion Control Systems for Industrial and Power Station Boilers," by J. L. Hodgson and L. L. Robinson, Proceedings of the Institution of Mechanical Engineers, vol. 126, 1934, pp. 59–169.

half cycle instead of the complete cycle of oscillation. However, Zucrow's Equations [31*a*], [31*b*], and [31*c*], and Fig. 6 of this discussion are noteworthy, although stated to be based on the work of Wünsch.[20] Actually it must be remembered that all of these equations neglect the water-hammer effects which occur when a control valve is moved rapidly, i.e., the momentary increase in velocity-pressure resulting from the destruction of the momentum of the fluid in a pipe while the control valve is being closed producing a momentarily increased velocity therethrough.[38]

Mitereff's remarks are stimulating and on the purely mathematical side. At the same time, it seems to the author that Mitereff's mathematical generalization based on Fig. 7 of this discussion, does not aid in the visualization of typical industrial regulators. Indeed, any such mathematical abstractions become dangerous when they become so far divorced from reality as to hinder the offhand recognition of equivalents, and thus deprive the engineer and inventor of the benefit of the check of his instinctive qualitative judgments based upon his practical experience with such devices. Offhand, Mitereff's device shown in Fig. 7 of this discussion does not seem to represent the several sources of damping and lag noted by Smith, Zucrow, and the author. As to the problem of turbine regulation, the closure's first reference[33] shows the present state of the art for steam turbines while other references[39,40] show the state of the water-turbine regulation art to be more advanced in 1930 than indicated by the context of Mitereff's Equation [36].

The simple electrical analogy used by Fairchild is correct as far as it applies, which is only to "corresponding" regulators. It states broadly that with level regulation having capacity lag, there is a lag of 90 deg between controller and meter, which capacity lag cannot produce hunting in the absence of meter response lag. This raises the point that valve speed is relatively important. Consider any "noncorresponding" regulator for a given capacity lag in which the pilot supply and consequently the control-valve speed has gradually been increased until the stability is small. A further large increase of capacity lag will permit the valve to overtravel its proper control position long before the level has changed appreciably. With a reservoir of infinite size, it is apparent that any finite valve speed and any finite stiffness of reset spring (in Class VII) will cause the valve to have unstable two-position regulation, even without the introduction of any metering lag. In other words, the stability is related to the capacity of the reservoir as well as to the reset spring stiffness and valve speed. Fairchild, Smith, and Stewart[41] mentioned another lag frequently met with in temperature regulation. This lag is the delay in transporting a heating medium from the controlling to the metering point which lag produces a phase angle depending upon the distance transported; in extreme cases the lag can be so great as to produce an apparently leading phase angle in a steadily hunting system.

The Downing discussion offers "variable detector" as a substitute for "meter" in the author's paper. "Senser" and "responder," respectively for "variable sensitive means" and "variable responsive means," are the only substitutes for "meter" that the author personally would consider acceptable. However, the Downing offering will receive consideration by the group. The Downing discussion presents an interesting side light on classification according to the number of variables, besides demonstrating the practical necessity for reaching agreement on terminology.

Yellott's discussion raises the point as to controller "speed," an important and convenient term that is commonly understood as the percentage of full controller travel per unit of time, a value immediately obtainable from the length of time required for the controller to move through its full travel. This use of "speed" seems preferable to introducing another "period" in a system where there already are two time durations: the period T of a complete hunting cycle and the interval t_i required for the amplitude of the hunting oscillations to drop to 10 per cent of their value at the start thereof.

Apparently Kimball's "self-centering and self-restoring" principle is that described in the paper under the Class XII regulator; see Fig. 17 of the paper as corrected in Fig. 3 of the Grebe discussion.

The author particularly welcomes Carter's suggestion for increasing the value of the proposed report to the important field of regulators used in power stations.

The Lowe discussion expresses encouragement and appreciation of efforts to standardize the terminology and simplify the presentation of the theory and practice of regulation. Such ideas must be shared by firms, such as he is associated with, to make possible effective work on this program. The author is glad to have this opportunity of thanking Chairman Wichum for his consistent interest in and support of this work of an educational nature, Rolnick for his helpful comments from his detached viewpoint, and Boelter, whose friendly interest over a period of years is likewise appreciated by the author. Professor Boelter in a further communication has furnished an interesting reference[42] for a bibliography on the subject under discussion.

In conclusion, this subject is of present and increasing importance to industry and engineers therein. The author urges all concerned to cooperate actively in forwarding a program that will at least reduce the present "lag" between the progress of industrial regulators and their technical literature. Unfortunately most of the burden of this work must necessarily fall upon the more numerous users since the limited technical staffs of the much fewer regulator manufacturers are generally unavailable or without adequate stenographic assistance for this task. After all, these reports are intended for the use of the industrial engineers and their associated staffs rather than for the purpose of reference for designers of regulators. However, the active cooperation of both groups is essential and to their mutual interest.

[38] "The Gibson Method and Apparatus for Measuring the Flow of Water in Closed Conduits," by N. R. Gibson, Trans. A.S.M.E., vol. 45, 1923, pp. 343–392.

[39] "Changing Requirements in Hydraulic-Turbine Speed Regulation," by F. Nagler, Trans. A.S.M.E., vol. 52, part 1, 1930, paper HYD-52-2, p. 13.

[40] "Mechanics of Hydraulic-Turbine Pressure Regulation," by A. Pfau, Trans. A.S.M.E., vol. 52, part 1, 1930, paper HYD-52-4, p. 29.

[41] Mentioned in the introduction of the paper.

[42] "Physicalische Kontrolle und Regulierung des Betriebes," vol. 2, part 1, "Kontroll- und Reguliereinrightungen," and part 2, "Mengenmessungen in Betriebe," Eucken-Jakob (8 parts) der chemie Ingenieur.

The Accuracy of the Cleanliness-Factor Measurement for Surface Condensers[1]

Joseph Gershberg.[2] The proper criterion for the accuracy of sampling with old test tubes is the agreement between the average heat transmittance of these tubes and that of the entire condenser. Comparison of values of U given in Table 1 of the paper shows that the average heat transmittance for four loads on each day of test as determined by old test tubes differs from

[1] Published as paper FSP-58-5, by P. H. Hardie and W. S. Cooper, in the July, 1936, issue of the A.S.M.E. Transactions.

[2] Chief Testing Engineer, The New York Edison Company, Inc., New York, N. Y. Mem. A.S.M.E.

the similar average for the entire condenser by —0.4 per cent on the first day (runs 1 to 4), —5.3 per cent on the second day, +1.0 per cent on the third day, and —2.0 per cent on the fourth day. Correction for average fouling does not alter these differences appreciably. Average cleanliness factors computed on the basis of a correct constant overall value of U_n, which would obtain if an adequate number of new sampling tubes were employed, therefore, will indicate the same disparity between a sample of old tubes recommended by the authors and the entire condenser as in the case of heat transmittances. Inadequacy of six new tubes in a sample of 24 tubes to represent correctly the entire condenser can be readily recognized from the study of values of U_n computed from the data in Table 1 of the paper. Comparison of average U_n for a 24-tube sample with that for a 96-tube sample shows a difference of +0.1 per cent for runs on the first day, —2.2 per cent on the second day, +4.0 per cent on the third day, and —2.0 per cent on the fourth day. It is to be noted that U_n is practically the same on the second and fourth days, which fact definitely indicates that the error in cleanliness factor due to a 24-tube sample on those days is —5.3 per cent and —2.0 per cent, respectively. Yet according to authors' method of comparison these errors are —1.8 per cent and + 1.8 per cent. The discrepancy is obviously masked by deviations of heat transmittances from a true value in both new and old tubes of 24-tube samples.

The authors' tests show quite conclusively the futility of obtaining assured accuracy of sampling with old tubes. Why such a sample after all? It is not justified, since the value of the bulk can be readily determined. Would it not be better to measure the heat transmittance of the entire condenser and to establish a fairly accurate value of U_n by use of an adequate number of new tubes judiciously distributed throughout the condenser? It seems a greater accuracy in the measurement of cleanliness factor will be thus obtained, perhaps at less cost.

J. F. Grace.[3] The authors determined, as shown in Table 2 of the paper, that the average cleanliness factor for the 96 tubes was 0.509 and that the average heat transmittance U_n of new tubes was 596 Btu. For the sample tubes in the front-line groups such as N, P, R, and S near the steam entrance to the condenser, the authors' Table 2 shows for group N that $CF = 0.478$ and $U_n = 715$ Btu, for group P that $CF = 0.478$ and $U_n = 694$ Btu, for group R that $CF = 0.486$ and $U_n = 737$ Btu, and for group S that $CF = 0.456$ and $U_n = 677$ Btu. These values show that the heat transmittance of these groups is above the average of the 24 clean sample tubes and that the cleanliness factors of the adjoining foul sample tubes are below the reported average cleanliness. In such groups as Q, W, and T, adjoining the front-line groups, the authors' Table 2 shows for group Q that $CF = 0.536$ and $U_n = 592$ Btu, for group W that $CF = 0.525$ and $U_n = 532$, and group T that $CF = 0.575$ and $U_n = 480$. The heat transmittances of these groups are below the average of the 24 clean sample tubes while the cleanliness factors are above the average.

These values coincide with those given by Seider[4] and by Tinker[5] which indicate that the same thickness of film which reduces transmittance 17 per cent below a clean-surface performance of 500 Btu will reduce transmittance 25 per cent below a clean-surface performance of 800 Btu shown by a high heat-transfer tube closer to the steam entrance or favored by higher water velocity.

Therefore, if front-line sample groups in locations where tubes are widely spaced, such as groups N, P, R, and S in the authors' Fig. 1, represent less than average condensation per sample group and also reduce the cleanliness factor calculated for the entire condenser, they are largely, if not entirely, responsible for the bend in the diagonal line plotted in Fig. 4 of the paper. This effect is to the advantage of the manufacturer and to the disadvantage of the owner.

Choice of location or weighting to represent equal weight of condensation per sample group may thus prove of greater importance than the number of groups of sample tubes.

Paul Bancel.[6] It is noted that runs 9 to 12, inclusive, in the authors' Table 1 give results of condenser performance about the middle of the four-day test period. The cleanliness factors obtained during these runs agree closely with the results for mean cleanliness conditions given in Table 2 of the paper. It is observed from the authors' Table 2 that runs 9 to 12, inclusive, include tests of isolated groups of top tubes N and R and that the heat transmittances of these groups are the highest isolated values attained under the prevailing cleanliness.

If all the tubes in the condenser could have been top tubes, which is an ideal condition of 100 per cent tube-nest efficiency, they would have worked at the transmittance rates of groups N and R, or approximately 350 Btu. Table 1 of this discussion shows that the actual performance during the maximum-load run No. 12 was 87.5 per cent of the performance of groups N and R. This is the apparent tube-nest efficiency and is analogous to the Rankine cycle efficiency of a turbine. The average for all loads, as noted in Table 1 of this discussion, was 83.5 per cent.

It is true that the average cleanliness factor for groups N and R is 0.482 whereas it is 0.504 for the entire condenser during runs 9, 10, 11, and 12, because the lower tubes are progressively cleaner. This is an advantage of the particular design. The tube-nest efficiency referred to top tubes under the existing conditions profits by reason of the design and is correspondingly higher than it would be with clean tubes.

TABLE 1 TEST PERFORMANCE OF TUBES DURING RUNS 9 TO 12

Run no.	Load 10^6 Btu	Observed CF	U	CF from Table 2[a]	U_c	U_o for groups N and R	U_c/U_o per cent
11	559	0.50	275	0.509	280	345	81.0
10	690	0.50	284	0.511	290	349	83.0
9	907	0.50	291	0.507	295	356	83.0
12	1239	0.48	298	0.490	305	349	87.5
Avg.	..	0.495	287	0.504	293	350	83.5

[a] Values taken from Table 2 of the paper.
CF = cleanliness factor.
U = overall condenser heat transmittance, Btu per hr per sq ft per deg F log mean-temperature difference.
U_c = overall condenser heat transmittance corrected.
U_o = heat transmittance for old tubes.

H. G. Hiebeler.[7] The authors have in this, and in their previous paper,[8] made important contributions to the art of measurements of performance of steam-condensing units. The last three condensers at the Deepwater (Houston) station have been the subject of check for the comparison of performance with manufacturers' guarantees. The testing methods were substantially

[3] Condenser Engineer, Worthington Pump and Machinery Corporation, Harrison, N. J. Mem. A.S.M.E.

[4] "Application of Fouling Factors in the Design of Heat Exchangers," by E. N. Seider, Fig. 6. This paper was presented at the Annual Meeting of The American Society of Mechanical Engineers, held in New York, N. Y., December 4 to 8, 1933, and was printed in a special publication "Heat Transfer," by the A.S.M.E.

[5] "Surface Condenser Design and Operating Characteristics," by T. Tinker, presented at the Semi-Annual Meeting of The American Society of Mechanical Engineers held at Chicago, June 25 to July 1, 1933. This paper received the A.S.M.E. Junior award for 1933.

[6] Ingersoll-Rand Company, New York, N. Y.

[7] Assistant Superintendent of Power, Houston Lighting & Power Co., Houston, Texas. Mem. A.S.M.E.

[8] "A Test Method for Determining the Quantitative Effect of Tube Fouling on Condenser Performance," by P. H. Hardie and W. S. Cooper, Trans. A.S.M.E., vol. 55, 1933, paper RP-55-3, p. 37.

those developed at Brooklyn and described by the authors in their previous paper.

It hardly seems necessary, in view of the thorough manner in which the Brooklyn Edison data have been prepared and analyzed, to review the similar data from the Deepwater tests and the writer will confine himself to commenting on the results obtaining on the tests of the last condenser, a 35,000-sq ft single-pass unit, having 6370 tubes, $^7/_8$ in. OD, no 18 Bwg, 24 ft long, serving a 35,000 kw turbine. Two two-speed circulating pumps having a combined total delivery of 63,000 and 87,000 gpm, respectively on low and high speeds were installed.

A series of 42 tests were run of an average duration of 50 minutes each with readings recorded simultaneously at five-minute intervals. Data were taken with machine loading corresponding to approximately one-half, three-fourths, and full-rated machine capacity. The condensate was measured by a calibrated venturi meter and all heat-transmittance calculations were based on the absolute pressure and temperature existent near the condenser inlet throat since the guarantee specified the back pressure should be measured within 24 inches of the turbine-exhaust opening. For the temperature and pressure conditions of these tests and the design of the condenser there was apparently very low pressure drop through and around the tube bundle.

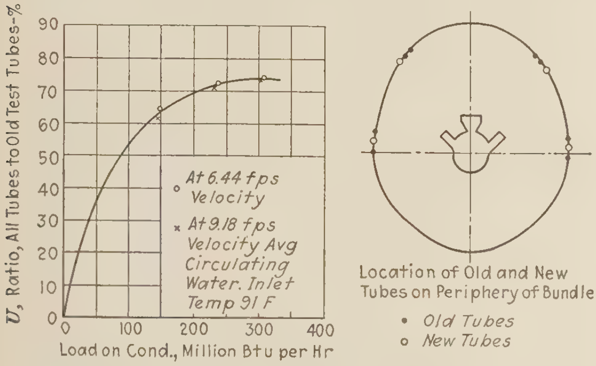


FIG. 1 RELATION OF HEAT-TRANSMITTANCE RATE OF OLD TEST TUBES ON THE PERIPHERY OF A BUNDLE TO THAT OF THE CONDENSER AS A WHOLE

The number of test tubes used in each series was twelve, comprising four groups of one clean and two dirty tubes in each of four quadrants. These tubes were selected at random adjacent to or on the periphery of the tube bank. It was felt that in such locations the tubes would receive sufficient quantity of steam to satisfy their individual capacities to condense. Such location would also probably give high temperature rise increasing the accuracy of measurement. It is believed that the cleanliness factor as found by the use of the tubes on the outside of the bundle reflects the condition throughout the test bundle within the limits of accuracy possible.

Fig. 1 of this discussion shows the relation of unit-transfer rate U of old test tubes on periphery of bundle to that of the condenser as a whole. This ratio might be considered an index or a measure of "bank efficiency" or steam penetration and seems independent of water velocity or tube cleanliness (through test range) but varies with the loading of the unit.

The writer cannot wholly agree with the authors' conclusion that less than sixteen test tubes give inaccurate or incorrect results on units of 7500 or less tubes. Small condensers do not warrant the refinement in testing possible with larger units and this factor should be considered. We check the authors' conclusion that cleanliness-factor relation to overall performance is not a straight line but the test range for our tests (53–87 per cent) was too short to draw definite conclusion as to the shape of the curve or the effect of circulating temperature variation (88–94 F) through these tests.

Considerable variation was found in the transfer rates of new tubes, a total of 28 new tubes being tested in one condenser alone. A variation in excess of 10 per cent each way from the average of 28 tests at comparable temperatures and velocities was obtained on both the high- and low-speed runs. This could not be explained on the basis of location of the tubes or other recognizable factors and raised the question as to how closely it was possible to determine condenser cleanliness until the standard against which it is measured is more definitely fixed. While agreeing with the authors that tests should be made in place in the condenser, and with circulating water from main sources which was also done in the writer's case, it is believed that considerable work with the tube calorimeter might be done to determine how much variation in performance might be expected between "new tubes" as received from the manufacturer or taken from stock. Some new tubes were tested exactly as received, some after being flushed with gasoline or benzene to cut any grease that might be present (this at the suggestion of the condenser manufacturer) with no discernible effects in reducing the variation in heat-transfer rates between several new tubes.

It might be added that the condenser was expected to meet performance with 90 per cent tube cleanliness as referred to new tubes. The 10 per cent allowance represented design margin allowed to take care of the formation of oxide film on the outside and other factors. It was recognized that 100 per cent cleanliness would never be obtainable in service and it was assumed that 90 per cent would represent the maximum condenser cleanliness obtainable by the best possible cleaning methods under operating conditions. The 10 per cent may be thought of as representing factors common to any condenser and not attributable to local water conditions. It is interesting to note that the condenser cleanliness factor averaged about 75 per cent and varied from 53 to 87 per cent of new tubes on the same test. Several mechanical methods of cleaning were tried. Best results seemed to be obtained by rodding with wire brushes. Incidentally the variation in cleanliness factor could not be attributed to the variation in heat-transfer rates of new tubes although apparently this influenced it somewhat.

It would appear that the whole question of determining condenser performance hinges on the ability to measure with reasonable accuracy the water pumped, the steam condensed, the quality or the heat content of the steam condensed, and the absolute pressure in the condenser shell. It is believed that the measurement of water temperatures, the steam condensed, and the quantity of water flowing through the test tubes as outlined in the authors' previous article can be done very accurately. However, the measurement of the water pumped and determination of heat content of the steam to the condenser are more difficult as is the measurement of vacuum. The mercury-column gages and temperature readings indicate a wide discrepancy at several points in the condenser neck as might be expected. Final-check agreement of absolute pressures as measured by the columns and the thermometers was obtained within 0.02 in. Hg after all possible care was used to avoid impingement or eddy effects. For the vacuum conditions and steam velocities of this installation these effects are probably of small magnitude compared to those which would be secured with lower absolute pressures and higher velocities obtaining under colder-water installations.

It is felt therefore that the tests which were conducted have contributed much to the knowledge of condensers, to the maintenance of performance of such units, but one cannot feel wholly satisfied that under the present conditions or the

methods outlined the absolute performance of a unit is closely measurable. The authors are considered on the right track but refinement of testing methods and further investigation are necessary before drawing any but very general conclusions.

Authors' Closure

Mr. Gershberg, in basing his analysis entirely on the values of heat transmittance, has obviously missed an important point which was covered in the paper, namely, that the heat transmittance is affected by several variables only one of which is the cleanliness factor. He has overlooked the fact that it is impossible to know, except very roughly, what sample-tube positions will be representative of the steam conditions throughout the tube bank. By making measurements on adjacent old and new tubes the authors avoided this pitfall.

Mr. Gershberg suggests that the cleanliness factor be determined by using the overall heat transmittance for U_o, and an adequate number of new test tubes to determine U_n. Although this method appears to have some advantages the authors do not believe it could be relied upon unless a large number of new tubes were employed. The positions selected, as pointed out in the preceding paragraph, would have an effect upon the results which could not be predicted. Furthermore, by increasing the number of new tubes to be installed the cost of the test is more likely to be increased than reduced.

Mr. Grace calls attention to the fact that the choice of sample-tube locations and the method of averaging are important as well as the number of sample tubes. The authors agree with Mr. Grace, but they wish to emphasize that if the sample tubes are distributed so that all parts of the condenser are represented, considerable latitude in selecting positions is possible without adversely affecting the results. This is illustrated in the test reported since the measurements of the overall cleanliness factor, using the different groups selected for each of the four days, gave approximately the same values.

Regarding the method of averaging, the overall cleanliness factor if properly determined must not only give weight to the individual values of the fouling according to the load on each section, but must also include a position factor, since the same degree of fouling does not reduce the heat transmittance the same in all positions. Mr. Grace seems concerned about what amounts to the position factor in the method of computation proposed. He implies, by his reference to the papers by Seider[4] and by Tinker,[5] that the fouling resistance R_f, where

$$R_f = \frac{1}{U_o} - \frac{1}{U_n} \qquad [1]$$

is a better expression to use than the cleanliness factor. As can be seen from this equation the fouling resistance is computed from the same data as the cleanliness factor. Either could be used. From the test data obtained so far, the fouling resistance seems to be almost unaffected by water velocity and the tube position, but susceptible to a much greater error than the cleanliness factor if the exact steam temperature at each tube is not known.

The fouling resistance may be a better indication of the condition of an individual tube. However, since the fouling resistance for each tube must be weighed by the position factor in order to determine the overall fouling resistance, there is no advantage in its use over the cleanliness factor which already includes the position factor as well as the condition factor. The authors, therefore, cannot agree with Mr. Grace's opinion that the method of computation used accounts for the bend in the diagonal line in Fig. 4 of the paper.

Messrs. Bancel and Hiebeler discuss another valuable use that can be made of the sample-tube data. The tube-nest or tube-bank efficiency is valuable information which should be determined on all condenser tests.

Mr. Hiebeler's discussion should prove very illuminating to any one attempting to make a cleanliness-factor measurement for the first time. While it is impossible to analyze the causes of his not feeling wholly satisfied with the results obtained from the cleanliness-factor measurements, the authors would like to point out a few things which they suspect might have reduced the accuracy otherwise obtainable. First of all, to assume that tubes in any one part of the condenser are representative of the entire condenser is open to question. Even though this were true, there would still be an appreciable error because the cleanliness factor includes the position factor (discussed previously) and only the outside positions were represented. A total of 24 test tubes instead of 12 would have undoubtedly given more consistent results.

It is true that new tubes are not an absolutely uniform standard but they are the best we have to work with. As much as 10 per cent variation in new tubes has also been noted by the authors, but when as many as six new tubes were used a fair average value has been obtained. Possibly, some of the disagreement between new tubes obtained by Mr. Hiebeler was due to other causes, such as, rapid fouling between the time of installation and the beginning of the test.

Mr. Hiebeler states that the cleanliness factor of the condenser at the Deepwater (Houston) station was expected to be 0.90 after cleaning, but that the nearest to this value actually obtained for an individual tube was 0.87 after trying several methods of cleaning, and the average was 0.75. This illustrates a point which the authors have been emphasizing, namely, that even though the cleanliness-factor measurement is not perfect it is reasonably reliable and certainly far better than any guess.

Failure of Metals Due to Cavitation Under Experimental Conditions[1]

Max Kurrein.[2] The author has presented some excellent micrographs showing variation of structure as a result of mechani-

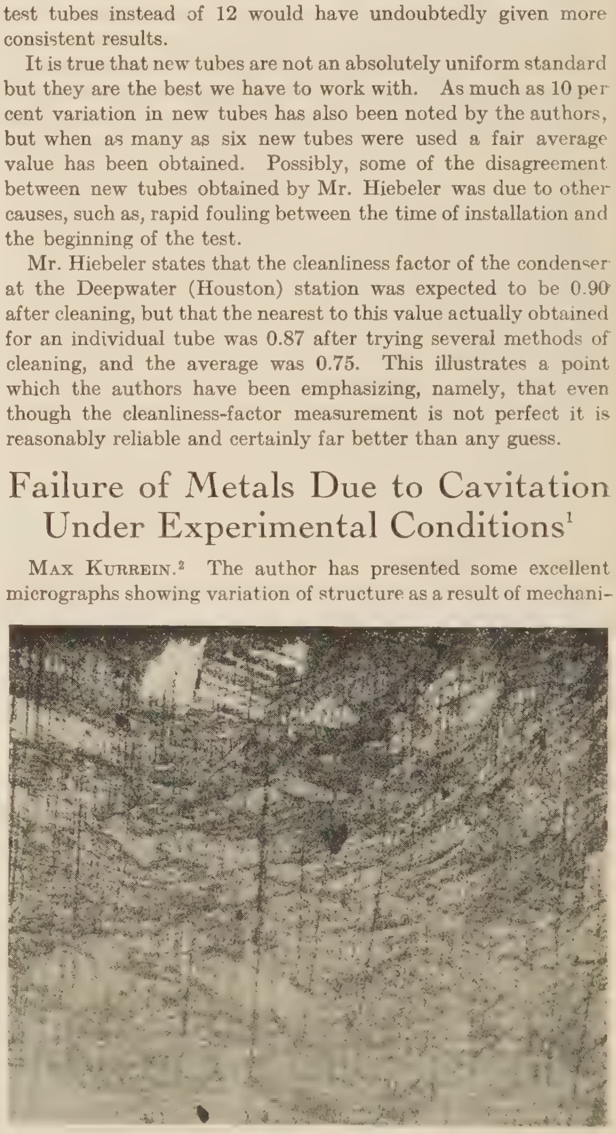


Fig. 1 Cracks in a Specimen Caused by a Punch Press Striking One Corner of the Specimen

[1] Published as paper HYD-58-1, by H. N. Boetcher, in the July, 1936, issue of the A.S.M.E. Transactions.

[2] Professor, Hebrew Technical College, Hadar Hacarmel, P.O.B. 955, Haifa, Palestine. Mem. A.S.M.E.

cal deformation due to outside forces. The author ascribes these variations to fatigue, that is, repeated impacts each of which is too small to produce the shown deformation. The writer would like to refer to Figs. 7*a* and 10 in particular. It has been known for more than 30 years that every outer deformation of a piece of work causes an adequate deformation of the microscopic structure in the grains of the material, but the writer believes that the author's Figs. 7*a* and 10 are the first examples of a similar relation due to fatigue. Assuming that the concentric deformation of the grains in Fig. 7*a* is caused by repeated impacts at one point near the middle of the upper portion of this figure, the writer would like to call the author's attention to Fig. 1 of this discussion.

Fig. 1 of this discussion, showing the same deformation as the author's Fig. 7*a*, was obtained by the writer while engaged in

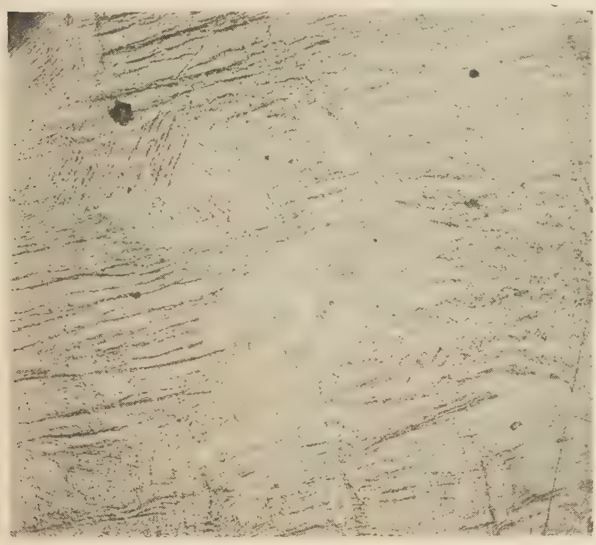


Fig. 2 Slips Bands on a Sheared Surface

research on certain punch press work. During the research study, the test piece was not parallel and was apparently struck on only one corner by the punch, thus distributing the deformation from a center.

Fig. 2 of this discussion, also obtained by the writer in the previously mentioned research, shows slip bands on a sheared surface, similar to those shown in the author's Fig. 10. As in the case of the author's tests, Fig. 2 of this discussion shows that the zone of influence penetrates on a sheared piece only a short depth from the sheared surface of the material. Beyond this depth the structure of the grains is not affected at all. Since the author's tests were made by impact and the writer's tests were made by application of a steady load, and the results of both tests showed the same characteristics, it would seem that the transmission of forces and deformation in loaded bodies must be sought in a direction heretofore not investigated.

Author's Closure

As Professor Kurrein states correctly, the deformation of the grain structure by outside forces, such as shown by his Fig. 1, is a well-known and rather commonplace condition. The appearance of slip bands under fatigue conditions is not a novel discovery either. I refer, for instance, to many excellent illustrations in H. J. Gough's book on "The Fatigue of Metals" as published in 1924.

The peculiarities of cavitation make it inadvisable to assume concentration of repeated impact stresses in any one spot as suggested by Professor Kurrein. Cavitation, especially under the accelerated conditions of the tests, exposes the affected surface to a series of blows hitting it in very much the same manner as a rain shower does the ground. Investigational work carried out after presentation of the paper at the 1935 Annual Meeting of the A.S.M.E. and intended to establish the reasons for the apparent lack of influence of corrosion resistance on cavitation fatigue showed the rain of blows to result in a kneading action with stresses exceeding the yield strength of even the strongest metals in a surface layer. This overstressed layer, though often extremely thin, absorbs the effects of corrosion and makes it possible for fatigue failures to appear and progress in the underlying metal depending entirely on mechanical properties and conditions. Further details are given in a paper by the author which appeared in *Zeitschrift, V.D.I.*, vol. 80, December 12, 1936, p. 1499.

Arc Welding Structural Alloy Steels[1]

F. T. Llewellyn.[2] Although this paper is admittedly only a progress report, it presents valuable information relative to a large and meritorious program of investigation that is being carried out by the author at the Watertown Arsenal. While many of the results will have wide application, the writer believes that the title of the paper should be qualified by some such phrase as, "especially as applied to the construction of ordnance." Otherwise there is the danger of assuming that the conclusions are directly applicable in all fields of welding.

The author recommends that a maximum limit of 0.25 per cent be set on the carbon content of weldable alloy steels. A suspicion arises that he rather expects steel makers to take issue on this point. The writer sees no reason to do so. Indeed, it is his reaction that, in some cases, the author's proposed limit may be too liberal.

The report lists 13 different grades of low-alloy high-tensile steel. Apparently the only properties on which tests have so far been completed are ultimate and yield-point values. Based on these properties alone, the author presents a comparison by the aid of which he suggests that designers may select the grade which should most satisfactorily meet their strength requirements. The author quite properly points out, however, that other factors may change the desirability of any of these steels for a given welded structure.

It is assumed that the final report will present a more comprehensive classification that takes impact resistance into consideration. The behavior of a few of the grades under tension impact is shown in the charts and doubtless, when all the tests have been completed, the author will present another classification in which all the results are included. Meanwhile, designers should recognize that the comparison is not yet complete.

In addition to the properties included in the Watertown investigation, there are frequently cases where resistance to fatigue and to corrosion become critical. These properties also should be considered in any attempt at a general ranking. In industrial applications the comparative cost per pound of the respective steels is another feature which will sometimes determine their optimum suitability in a design.

The author is to be congratulated on this progress report. His final report will be awaited with interest.

---

[1] Published as paper MSP-58-3, by W. L. Warner, in the October, 1936, issue of the A.S.M.E. Transactions.

[2] Research Engineer, United States Steel Corporation, New York, N. Y.

Operating Experience With Pulverized Texas Lignite in a Large Central Station[1]

H. E. Martin.[2] The author has recorded in a broad and interesting manner a development having significance from a variety of angles. The fact that Texas lignite continues to be used at the Trinidad station in competition with the oil and gas fuels that are now available at low cost, has demonstrated the feasibility of utilizing this fuel as a prime source of power generation. Texas is thus assured that its enormous lignite resources will constitute a source of cheap power regardless of the market and supply conditions in the more popular oil and gas fuels. Greater use of this fuel may be expected.

The author points to low fuel costs at the plant and desired availability of equipment as being controlling factors in the design of the plant. This has resulted in designs and arrangements of equipment that for this size of plant are unique in their simplicity, of which the single-pass boilers operated on natural draft without air heaters or economizers are examples. The simplicity of this station may be studied with profit by other designers, especially for locations where fuel is cheap.

Those interested in the extension of the use of pulverized fuel will take satisfaction in observing this large commercially successful installation using low-grade lignites as fuel. The bin system of pulverized-fuel firing is used, although since the initial installation was made in this station the direct-fired system has come into more general use, and it is to be expected that in future installations consideration will be given to this still simpler and less expensive system. The author's comments on the problems involved in such a system based on his observations would be of value.

The high moisture content to be evaporated in the furnace together with the rather large areas of bare-tube waterwalls are responsible for low furnace temperatures. It would be interesting to know the effect of hotter furnaces on performance and more especially on the superheat curve, which the author states is steeper than anticipated.

It will be noted that the boilers installed in 1931 are of the cross-drum single-pass type with converging gas pass. The boiler has a low draft loss and is ideally adapted to natural-draft operation. No capacity limitations of any kind appear to have been reached in connection with the boiler.

The designers and operators are to be congratulated on the performance of this station. If the plant were to be built today taking advantage of the latest developments, it is quite safe to predict that pulverized fuel would be retained, as would simplicity of design and moderate efficiencies. Modifications would likely be made in arrangements of equipment and of heating surfaces made available since the existing plant was built.

[1] Published as paper FSP-58-4, by Norman G. Hardy, in the May, 1936, issue of the A.S.M.E. Transactions.

[2] Babcock & Wilcox Company, New York, N. Y. Mem. A.S.M.E.

NOTICE TO AUTHORS on the Preparation of Manuscripts

THE most satisfactory and economical results in publishing technical papers are obtained with the most carefully prepared manuscripts. Observance of the few simple rules which follow will help to assure correctly printed papers at minimum cost.

Length: Be brief. Eliminate unnecessary words, descriptions, data, drawings, charts, illustrations, tables, mathematics. Papers requiring more than eight pages when printed are likely to be returned for condensation or rejected. Solid type runs 1200 words per page. Allow extra for the title, footnotes, bibliography, illustrations, and mathematics.

Manuscripts: Typewrite, double or triple space, on one side of standard-size paper. Leave ample margins. Cut captions, on a separate sheet, illustrations, and tables should accompany manuscript.

Bibliography: Footnotes and bibliographical references must be complete and thoroughly checked for accuracy. Do not abbreviate. Put in A.S.M.E. style: Title, author, name of periodical, volume and number, date, page. If a book: Title, author, publisher, place of publication, date, page referred to.

Mathematics: Check carefully. Write symbols clearly. Distinguish between capital and lower case letters. Mark zero to avoid confusion with letter O; numeral 1 with the letter "el" (l) or prime (′); Greek letters (alpha with a, kappa with k). Mark subscripts and exponents clearly. Avoid dots and bars over letters.

Illustrations: Good halftones are made from good photographs. Send black and white photographic prints, not blueprints or other halftones. Make drawings, graphs, and diagrams as simple as possible. Put explanatory notes in captions rather than on the graphs. Use black ink and white paper, or preferably tracing cloth. Letter in pencil; relettering in ink will be done by A.S.M.E. draftsman for uniformity of size and appearance. Check thoroughly as changes cannot be made on the cuts.

Check Everything: Delay, expense, and errors in printed papers can be avoided only by careful and repeated checking. Changes in proof are unnecessary if manuscripts are thoroughly checked and are carefully and clearly prepared.

Help the Society to do a better publishing job at less expense by observing these simple rules when you prepare a manuscript.

A.S.M.E. Publications Committee

MEMBERSHIP LIST
AND SOCIETY RECORDS
PART 1, 1937

PUBLISHED BY

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 WEST 39TH STREET, NEW YORK, N. Y.

PRESIDENT

JAMES H. HERRON
1936-1937

PAST-PRESIDENTS
TREASURER AND SECRETARY

CONRAD N. LAUER
President, 1931-1932

Harris & Ewing

A. A. POTTER
President, 1932-1933

PAUL DOTY
President, 1933-1934

RALPH E. FLANDERS
President, 1934-1935

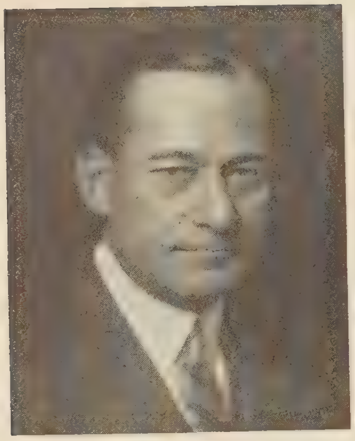
C. E. DAVIES
Secretary, 1934 to date

W. D. ENNIS
Treasurer, 1935 to date

WILLIAM L. BATT
President, 1935-1936

VICE-PRESIDENTS

ROBERT L. SACKETT
1935-1937



HARRY R. WESTCOTT
1936-1938

ALEX D. BAILEY
1935-1937

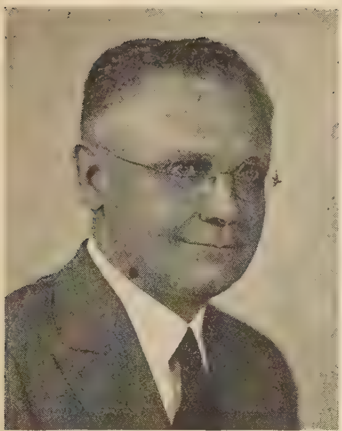
WILLIAM A. SHOUDY
1935-1937

R. J. S. PIGOTT
1936-1938

JOHN A. HUNTER
1935-1937

JAMES M. TODD
1936-1938

MANAGERS



ALFRED IDDLES
1934-1937

JILES W. HANEY
1934-1937

BENNETT M. BRIGMAN
1934-1937

W. C. LINDEMANN
1935-1938

JAMES W. PARKER
1935-1938

WM. LYLE DUDLEY
1935-1938

KENNETH H. CONDIT
1936-1939

SAMUEL W. DUDLEY
1936-1939

EDWARD W. BURBANK
1936-1939

FOREWORD

With the bringing together in this book of the personnel of the Council and committees of the Society, the alphabetical and geographical lists of members of all grades, including the members of the Student Branches, for the past two years published in the Student Branch Bulletin, there is made available in one place for the first time since 1931, a complete "yearbook" of information of this nature. This forms Part 1 of the Society Records for 1937, which is a section of the Transactions of The American Society of Mechanical Engineers. Parts 2 and 3 will contain the memorials of deceased members and indexes to publications.

The "RI" preceding page numbers in this section is the symbol for Record and Index, and these pages, as well as the later issues of the Society Records for the year, will form part of the bound volumes of Transactions of the Society.

The use of this section will be facilitated by reference to the index on pages RI-34 and 35.

Membership List

The Membership List itself contains the names of all those who were members ot the Society on December 1, 1936. It is divided into two sections. The Alphabetical List (page 1), which gives the name and location of each member, is the key to the Geographical List (page 37), which includes the member's grade of membership, his business connection, and his mail address.

The United States, including its territories and dependencies (Alaska, Canal Zone, Hawaii, Philippine Islands, and Puerto Rico) is placed first in the geographical list. It is followed by other countries in the Western Hemisphere, Canada, Newfoundland, Mexico, Central America, the West Indies, and South America, in the order enumerated. In the Eastern Hemisphere the individual countries are listed alphabetically under the headings Africa, Asia, Europe, and Oceania. Cross references to the territories and dependencies of the United States are inserted at the proper points, and other cross references cover variations in names of countries. Facing page 1 is an index giving the number of the page on which each country will be found.

In the United States and Canada, the name of each city which falls within a Local Section is followed by the name of that Section. Members residing in cities where no Section is mentioned may affiliate with any Section, without additional dues, upon request to the headquarters of the Society.

Where more than one address is given for a member, the first is the business address and is usually followed by the address to which he desires his mail sent. In some instances a "home address" is given. This was done in cases where members desired to be grouped under city headings which are not part of the business or mail addresses.

The dates and letter symbols in parentheses after the name of a member indicate his grade of membership and year of election or promotion to each grade. The letter sym-

bols are H - Honorary; F - Fellow; A - Associate; AM - Associate Member; and J - Junior.

Where a single date is not accompanied by a letter symbol, the grade of member is to be understood. Also where several dates are given, with no letter symbol, the final date indicates the year of election to full membership.

Restrictions On Use of Membership List

This Membership List is issued for the personal use of members of The American Society of Mechanical Engineers in connection with Society and professional affairs.

Each member is expected to conserve it and not to permit his copy to be used for the basis of circularization. Such use is annoying to fellow members.

The American Society of Mechanical Engineers

THE members of the Council and of its standing and special committees given on the following pages are those in office on January 1, 1937, serving for the official year 1936–1937. The terms of office of members of other committees are not fixed by the official calendar.

Officers and Council

PRESIDENT

James H. Herron

PAST-PRESIDENTS

Terms expire December

Conrad N. Lauer (1937)
A. A. Potter (1938)
Paul Doty (1939)
Ralph E. Flanders (1940)
William L. Batt (1941)

VICE-PRESIDENTS

Terms expire December, 1937

Alex D. Bailey
John A. Hunter
Robert L. Sackett
William A. Shoudy

Terms expire December, 1938

Harry R. Westcott (1937)*
James M. Todd
R. J. S. Pigott

MANAGERS

Terms expire December, 1937

Bennett M. Brigman
Jiles W. Haney
Alfred Iddles

Terms expire December, 1938

W. Lyle Dudley
Walter C. Lindemann
James W. Parker

Terms expire December, 1939

Edward W. Burbank
Kenneth H. Condit
Samuel W. Dudley

TREASURER

W. D. Ennis

SECRETARY

C. E. Davies

Chairmen of Standing Committees

Representatives on Council without vote

Finance, William T. Conlon
Meetings and Program, Harvey N. Davis
Publications, William F. Ryan
Admissions, R. H. McLain
Professional Divisions, Crosby Field
Local Sections, W. R. Woolrich
Constitution and By-Laws, H. H. Snelling
Honors and Awards, R. C. H. Heck
Relations with Colleges, Roy V. Wright
Education and Training for the Industries, C. J. Freund
Library, L. K. Sillcox
Research, N. E. Funk
Standardization, Walter Samans
Power Test Codes, Robert H. Fernald
Safety, Harry H. Judson
Professional Conduct, E. R. Fish

EXECUTIVE COMMITTEE OF COUNCIL

James H. Herron, *Chairman*
Kenneth H. Condit
James W. Parker
William A. Shoudy
Harry R. Westcott

Advisory Members: Chairmen of the Finance, Local Sections, and Professional Divisions Committees

SENIOR COUNCILLORS

(Numbers indicate Local Section Groups)

I—Harry R. Westcott
II—William A. Shoudy
III—Robert L. Sackett
IV—James M. Todd
V—Bennett M. Brigman
VI—Alex D. Bailey
VII—John A. Hunter

* Appointed for one year to fill term of James A. Hall.

ASSISTANT SECRETARIES

Ernest Hartford
C. B. LePage

EDITOR

G. A. Stetson

Standing Committees

FINANCE

W. T. Conlon, *Chairman and Representative on Council* (1938)
K. M. Irwin, *Vice-Chairman* (1939)
K. W. Jappe (1937)
J. J. Swan (1940)
J. L. Kopf (1941)

Council Representatives W. A. Shoudy (1937), W. L. Batt (1938)

MEETINGS AND PROGRAM

H. N. Davis, *Chairman and Representative on Council* (1937)
Clarke Freeman (1938)
R. F. Gagg (1939)
C. G. Stoll (1940)
W. J. Wohlenberg (1941)

Junior Advisor: W. W. Lawrence (1937)

PUBLICATIONS

W. F. Ryan, *Chairman and Representative on Council* (1937)
M. H. Roberts (1938)
G. F. Bateman (1939)
C. B. Peck (1940)
Coleman Sellers, 3d (1941)

Advisory Members (1937) W. L. Dudley, L. S. Marks, A. N. Goddard, J. M. Todd

Junior Advisors (1937) L. N. Rowley, Jr., L. F. Zsuffa

(*Personnel of Special Committee, p.* RI-5)

ADMISSIONS

R. H. McLain, *Chairman and Representative on Council* (1937)
L. R. Ford (1938)
F. C. Spencer (1939)
Norman Litchfield (1940)
H. E. Molé (1941)

Advisory Member: H. A. Lardner (1937)

PROFESSIONAL DIVISIONS

Crosby Field, *Chairman and Representative on Council* (1938)
G. B. Pegram (1937)
L. K. Sillcox (1939)
H. B. Reynolds (1940)
Victor Wichum (1941)

(*Personnel of Professional Divisions' Executive Committees, p.* RI-5)

LOCAL SECTIONS

W. R. Woolrich, *Chairman and Representative on Council* (1938)
J. N. Landis (1937)
D. B. Prentice (1939)
A. J. Kerr (1940)
H. L. Eggleston (1941)

(*Personnel of Local Sections' Executive Committees, p.* RI-10)

CONSTITUTION AND BY-LAWS

H. H. Snelling, *Chairman and Representative on Council* (1937)
W. H. Kavanaugh (1938)
R. D. Brizzolara (1939)
G. E. Hulse (1940)
S. R. Beitler (1941)

Junior Advisor: H. S. Eddy (1937)

HONORS AND AWARDS

R. C. H. Heck, *Chairman and Representative on Council* (1937)
L. P. Alford (1938)
Harte Cooke (1939)
W. H. Carrier (1940)
J. W. Roe (1941)

Junior Advisor: C. F. Pray (1937)

(*Personnel of Special Committee, p.* RI-5)

EDUCATION AND TRAINING FOR THE INDUSTRIES

C. J. Freund, *Chairman and Representative on Council* (1937)
John Younger (1938) Warner Seely (1940)
J. A. Randall (1939) J. H. Ploehn (1941)

RELATIONS WITH COLLEGES

R. V. Wright, *Chairman and Representative on Council* (1937)
W. A. Hanley (1938) H. O. Croft (1940)
F. V. Larkin (1939) E. W. O'Brien (1941)

W. J. Cope, R. L. Daugherty, R. H. G. Edmonds — *Advisory Members* (1937)

Junior Advisor: H. B. Fernald, Jr. (1937)

(*Student Branches and Officers, p.* RI-8)

LIBRARY

L. K. Sillcox, *Chairman and Representative on Council* (1937)
J. S. Kerins (1938) A. R. Mumford (1940)
The Secretary, C. E. Davies, *Ex-Officio*

RESEARCH

Organized in 1909 to supervise all research activities of the Society, to cooperate with similar committees of kindred societies, to encourage research, and to disseminate knowledge of researches conducted in the United States and in other countries

N. E. Funk, *Chairman and Representative on Council* (1939)
J. E. Gleason (1937) L. W. Wallace (1940)
H. A. Johnson (1938) E. G. Bailey (1941)

(*Personnel of Special Committees, p.* RI-17)

STANDARDIZATION

Organized in April, 1911, to supervise all standardization activities of the Society and to advise concerning the Society's participation in the activities of the American Standards Association

Walter Samans, *Chairman and Representative on Council* (1938)
J. E. Lovely (1937) W. C. Mueller (1940)
O. A. Leutwiler (1939) A. L. Baker (1941)

(*Personnel of Special Committees, p.* RI-19)

POWER TEST CODES

Organized December, 1918, to revise and extend the Power Test Codes of the Society. These codes had been formulated by various technical committees appointed to develop particular codes. This work began in 1886.

R. H. Fernald, *Chairman and Representative on Council* (1940)

Francis Hodgkinson, *Vice-Chairman*
W. G. Rothschild, *Junior Observer* (1937)

Term expires 1937
Harte Cooke
E. R. Fish
O. P. Hood
H. B. Oatley
W. J. Wohlenberg

Term expires 1938
Hans Dahlstrand
Louis Elliott
G. A. Horne
H. B. Reynolds
E. N. Trump

Term expires 1939
C. H. Berry
D. S. Jacobus
Francis Hodgkinson
L. F. Moody
E. B. Ricketts

Term expires 1940
A. T. Brown
R. H. Fernald
C. F. Hirshfeld
R. J. S. Pigott
M. C. Stuart

Term expires 1941
A. G. Christie
Paul Diserens
G. A. Orrok
L. A. Quayle
W. M. White

(*Personnel of Technical Committees, p.* RI-26)

SAFETY

Appointed in October, 1921, to extend the knowledge of accident prevention, to promote cooperation in this field, and to supervise all safety code activities of the Society with the exception of those of the Boiler Code group of committees

H. H. Judson, *Chairman and Representative on Council* (1937)
H. L. Miner (1938) D. L. Royer (1940)
J. B. Chalmers (1939) T. F. Hatch (1941)

(*Personnel of Special Committees, p.* RI-27)

PROFESSIONAL CONDUCT

E. R. Fish, *Chairman and Representative on Council* (1937)
E. F. Scott (1938) B. F. Wood (1940)
Hugo Diemer (1939) E. H. Tenney (1941)

Special Technical Committees

BOILER CODE

D. S. Jacobus, *Chairman*
E. R. Fish, *Vice-Chairman*
C. W. Obert, *Honorary Secretary*
M. Jurist, *Acting Secretary*
C. A. Adams
H. E. Aldrich
H. C. Boardman
W. H. Boehm
R. E. Cecil
F. S. Clark
A. J. Ely
V. M. Frost
C. E. Gorton
A. M. Greene, Jr.
F. B. Howell
W. G. Humpton
J. O. Leech
I. E. Moultrop
C. O. Myers
H. B. Oatley
James Partington
Walter Samans
S. K. Varnes
A. C. Weigel
H. LeRoy Whitney

Honorary Members

F. W. Dean
W. F. Durand
T. E. Durban
C. L. Huston
W. F. Kiesel
M. F. Moore
H. H. Vaughan

Conference Committee to the Boiler Code Committee

T. R. Archer, Delaware
L. M. Barringer, Seattle, Wash.
A. J. Beauregard, Rhode Island
Wm. Betz, Jr., Philadelphia, Pa.
J. G. Bollock, St. Joseph, Mo.
B. M. Book, Pennsylvania
J. C. Bryan, St. Louis, Mo.
T. C. Cannon, Tulsa, Okla.
L. M. Cave, Maryland
A. L. Daniels, Parkersburg, W. Va.
James Donohue, Indiana
M. A. Edgar, Wisconsin
C. W. Foster, Omaha, Nebraska
W. H. Furman, New York
F. D. Garrin, Houston, Tex.
Gerald Gearon, Chicago, Ill.
E. M. Goodman, Evanston, Ill.
C. H. Gram, Oregon
P. M. Greenlaw, District of Columbia
B. Gretzke, Washington
F. A. Hecklinger, Memphis, Tenn.
G. A. Luck, Massachusetts
J. M. Lynch, Erie, Pa.
C. E. McGinnis, Los Angeles, Calif.
H. H. Mills, Detroit, Mich.
A. C. Mitchell, Scranton, Pa.
C. O. Myers, Ohio
J. D. Newcomb, Jr., Arkansas
W. L. Newton, Oklahoma
Daniel O'Connor, Michigan
F. A. Page, California
L. C. Peal, Nashville, Tenn.
J. J. Ryan, Kansas City, Mo.
E. K. Sawyer, Maine
A. H. Schleman, Tampa, Florida
J. F. Scott, New Jersey
W. E. Shuping, Jr., N. Carolina
C. I. Smith, Utah
Wm. E. Smith, Hawaiian Islands
George Wilcox, Minnesota

Executive Committee

D. S. Jacobus, *Chairman*
H. E. Aldrich
W. H. Boehm
E. R. Fish
V. M. Frost
C. E. Gorton
C. W. Obert
James Partington

Subcommittee on Boilers of Locomotives

James Partington, *Chairman*
F. H. Clark
J. M. Hall
H. B. Oatley

Subcommittee on Care of Steam Boilers and Other Pressure Vessels in Service

F. M. Gibson, *Chairman*
V. M. Frost
J. R. Gill
J. A. Hunter
H. J. Kerr
S. T. Powell
C. W. Rice
H. F. Scott
Nicholas Stahl
F. G. Straub

Subcommittee on Ferrous Materials

H. LeRoy Whitney, *Chairman*
A. J. Ely, *Vice-Chairman*
H. J. French
H. W. Gillette
W. G. Humpton
J. J. Kanter
E. F. Kenney
H. J. Kerr
A. B. Kinzel
L. A. Sheldon
A. E. White
E. C. Wright

Subcommittee on Heating Boilers

F. B. Howell, *Chairman*
W. H. Boehm
C. E. Bronson
J. A. Darts
C. E. Gorton
F. W. Herendeen
W. E. Stark
J. W. Turner

Subcommittee on Material Specifications

Members of A.S.M.E. Boiler Code Committee

P. R. Cassidy, *Chairman*
A. M. Greene, Jr.
J. O. Leech
P. J. Smith

Members of Conference Committee of American Society for Testing Materials

C. L. Warwick, *Chairman*
E. J. Edwards
C. F. W. Rys

Members of Conference Committee of Association of American Steel Manufacturers, Technical Committees

J. O. Leech, *Chairman*
E. F. Kenney
A. D. Peace

Subcommittee on Miniature Boilers

C. E. Gorton, *Chairman*
James Partington, *Vice-Chairman*
E. R. Fish
W. H. Furman
G. A. Luck
C. O. Myers
C. W. Obert

Subcommittee on Non-Ferrous Materials

H. B. Oatley, *Chairman*
J. J. Aull
D. K. Crampton
A. M. Houser
F. P. Huston
H. C. Jennison
E. F. Miller
Joseph Price

Subcommittee on Rules for Inspection

J. A. Collins, *Chairman*
S. H. Barnum
L. E. Connelly
William Ferguson
C. E. Gorton
F. W. Herendeen
James Partington

Subcommittee on Special Design

D. B. Wesstrom, *Chairman*
W. L. Bowler
R. E. Cecil
H. E. Rockefeller
D. B. Rossheim
W. H. Rowand
E. O. Waters
F. S. G. Williams

Subcommittee on Unfired Pressure Vessels

E. R. Fish, *Chairman*
C. A. Adams
W. H. Boehm
C. E. Bronson
R. E. Cecil
Paul Diserens
A. W. Limont, Jr.
H. S. Smith
D. B. Wesstrom

Subcommittee on Welding

Members of A.S.M.E. Boiler Code Committee

James Partington, *Chairman*
C. A. Adams
A. M. Candy
R. E. Cecil
J. H. Deppeler
E. R. Fish
R. K. Hopkins
T. McLean Jasper
L. A. Sheldon

Members of Conference Committee of American Welding Society

C. W. Obert, *Chairman*
J. J. Crowe
E. H. Ewertz
F. C. Fyke
A. Kidd
H. E. Rockefeller
J. W. Owens
L. H. Roller

Special Committee on Rules for Bolted Flanged Connections

D. B. Wesstrom, *Chairman*

Special Committee on Rules for Openings

T. D. Tifft, *Chairman*

Special Committee on Radiographic Examination of Welded Joints

C. A. Adams, *Chairman*

Special Committee on Alloyed and High Tensile Steels for Welded Pressure Vessels

C. A. Adams, *Chairman*

Special Committee to Revise Section VIII of the A.S.M.E. Boiler Code

E. R. Fish, *Chairman*

Special Committee on Rules for Containers for Gases and Liquids at Subzero Temperatures

H. LeRoy Whitney, *Chairman*

Special Committee on Clad Vessels

S. K. Varnes, *Chairman*

Special Committee on the Extension of Use of Fusion Welding Code Requirements

H. E. Aldrich, *Chairman*

API-ASME COMMITTEE ON UNFIRED PRESSURE VESSELS

A.S.M.E. Representatives

R. E. Cecil
E. R. Fish
D. S. Jacobus
T. McLean Jasper
James Partington

A.P.I. Representatives

Walter Samans, *Chairman*
A. J. Ely
R. C. Powell
K. V. King
(P. D. McElfish, *Alternate*)
T. D. Tifft

Special Administrative Committee

REGULAR NOMINATING COMMITTEE FOR 1937

GROUP

I Charles M. Allen, Worcester, Mass., *Chairman*
T. H. Beard, Bridgeport, Conn., *Alternate*

II F. M. Gibson, Brooklyn, N. Y., *Secretary*
E. G. Bailey, New York, N. Y., *1st Alternate*
W. E. Caldwell, New York, N. Y., *2nd Alternate*

III A. L. DeLeeuw, Plainfield, N. J.
Virgil M. Palmer, Rochester, N. Y., *Alternate*

IV B. E. Short, Austin, Texas
J. W. Eshelman, Birmingham, Ala., *Alternate*

V L. E. Jermy, Cleveland, Ohio
G. A. Young, Lafayette, Ind., *1st Alternate*
K. F. Treschow, Pittsburgh, Pa., *2nd Alternate*

VI A. A. Luebs, Lincoln, Neb.
C. F. Moulton, Omaha, Neb., *1st Alternate*
W. L. DeBaufre, Lincoln, Neb., *2nd Alternate*

VII J. C. Othus, Corvallis, Ore.
Paul L. Heslop, Portland, Ore., *1st Alternate*
Franklin L. Davis, Portland, Ore., *2nd Alternate*

LOCAL SECTIONS IN NOMINATING COMMITTEE GROUPS

GROUP I

Boston, Bridgeport, Green Mountain, Hartford, Meriden, New Britain, New Haven, Norwich, Providence, Waterbury, Western Massachusetts, Worcester

GROUP II

Metropolitan (N. Y.) and Foreign Members

GROUP III

Anthracite-Lehigh Valley, Baltimore, Central Pennsylvania, Ithaca, Philadelphia, Plainfield, Rochester, Schenectady, Susquehanna, Syracuse, Utica, Washington, D. C.

GROUP IV

Atlanta, Birmingham, Charlotte, Chattanooga, Florida, Greenville, Knoxville, Memphis, New Orleans, North Texas, Raleigh, Savannah, South Texas, Virginia

GROUP V

Akron-Canton, Buffalo, Central Indiana, Cincinnati, Cleveland, Columbus, Dayton, Detroit, Erie, Louisville, Ontario, Peninsula, Pittsburgh, Toledo, West Virginia, Youngstown

GROUP VI

Chicago, Kansas City, Mid-Continent, Milwaukee, Minnesota, Nebraska, Rock River Valley, St. Joseph Valley, St. Louis, Tri-Cities

GROUP VII

Colorado, Inland Empire, Los Angeles, Oregon, San Francisco, Utah, Western Washington

Special Council Committees

ADVISORY BOARD ON PROFESSIONAL STATUS

H. R. Westcott, *Chairman*
C. F. Hirshfeld, Engineers' Council for Professional Development
R. H. McLain, Admissions
V. M. Palmer, Registration
B. F. Wood, Professional Conduct

ADVISORY BOARD ON STANDARDS AND CODES

Alex D. Bailey, *Chairman*
V. M. Frost, Boiler Code
W. M. Graff, Safety
Francis Hodgkinson, Power Test Codes
O. A. Leutwiler, Standardization

ADVISORY BOARD ON TECHNOLOGY

Alfred Iddles, *Chairman*
G. F. Bateman, Publications
H. N. Davis, Meetings and Program
Crosby Field, Professional Divisions
L. W. Wallace, Research

AIMS AND OBJECTIVES

Alfred Iddles, *Chairman*; F. E. Cardullo; W. L. Edel; E. E. Howard; L. E. Jermy; R. G. Macy; E. W. O'Brien; G. B. Pegram; Elgin Stoddard

Ex-Officio

A. D. Bailey, Board on Standards and Codes
W. D. Ennis, Finance
J. P. Harbeson, Jr., Speaker, Delegates Conference, Annual Meeting
Alfred Iddles, Board on Technology
H. R. Westcott, Board on Professional Status

BOARD OF REVIEW (DELINQUENT MEMBERS)

J. P. Neff, *Chairman*; C. P. Bliss; S. D. Sprong

TRUSTEES FOR CERTIFICATES OF INDEBTEDNESS

W. D. Ennis; Erik Oberg; R. V. Wright

CITIZENSHIP (MANUAL ON)

A. R. Cullimore, *Chairman*; Lillian M. Gilbreth; J. W. Roe; W. H. Winterrowd; R. V. Wright

DEVELOPMENT

D. S. Kimball, *Chairman*; E. G. Bailey; W. S. Finlay, Jr.; G. A. Orrok; C. G. Spencer

ECONOMIC STATUS OF THE ENGINEER

C. F. Hirshfeld, *Chairman*; D. S. Kimball; C. N. Lauer; H. B. Oatley; H. L. Whittemore; W. E. Wickenden
Chairmen of Committees on Local Sections and Relations with Colleges — *Ex-Officio*

FREEMAN SCHOLARSHIP

Charles T. Main, *Chairman*; Clarke Freeman; E. C. Hutchinson

MANUAL OF PRACTICE

B. F. Wood, *Chairman*; Alfred Iddles; Wynn Meredith; J. M. Todd; M. X. Wilberding; E. R. Fish, *Ex-Officio*
Theodore Baumeister, Jr., *Acting Secretary*
Junior Advisor, Philip Werner

MECHANICAL CATALOG

W. T. Conlon; R. E. Thayer

NATIONAL DEFENSE

H. I. CONE, *Chairman*
H. E. COFFIN
W. C. DICKERMAN
T. A. MORGAN
J. L. WALSH
C. T. HARRIS (War Dept. Rep.)
A. M. R. ALLEN (Navy Dept. Rep.)

REGISTRATION

J. ROWLAND BROWN, *Chairman*
B. M. BRIGMAN
J. A. HUNTER
J. A. MCPHERSON
V. M. PALMER
R. J. REED
W. K. SIMPSON

CALVIN W. RICE MEMORIAL

H. N. DAVIS, *Chairman*
J. D. CUNNINGHAM
W. F. DURAND
C. E. FULLER
C. N. LAUER
E. W. O'BRIEN
J. W. PARKER
R. L. SACKETT

SPIRIT OF ST. LOUIS MEDAL BOARD OF AWARD

(*Dates in parentheses denote expiration of terms*)

V. J. AZBE, *Chairman* (1943)
J. H. DOOLITTLE, *Secretary* (1940)
H. I. CONE (1937)
W. B. MAYO (1937)
ORVILLE WRIGHT (1940)
C. B. MILLIKAN (1943)

GEORGE WESTINGHOUSE BUST

AMBROSE SWASEY, *Honorary Chairman*
D. S. KIMBALL, *Chairman*
L. B. STILLWELL, *Vice-Chairman*
C. E. DAVIES, *Secretary*
K. T. COMPTON
S. W. DUDLEY
C. N. LAUER
L. A. OSBORNE
C. F. SCOTT

Special Publications Committee

BIOGRAPHY ADVISORY COMMITTEE

R. V. WRIGHT, *Chairman*
L. P. ALFORD
R. E. FLANDERS
G. A. ORROK
J. W. ROE
W. H. WINTERROWD

Special Committee of the Board on Honors and Awards

COMMITTEE ON MEDALS

Terms expire 1937
R. C. H. HECK, *Chairman*
A. M. GREENE, JR.
J. W. PARKER
R. V. WRIGHT

Terms expire 1939
C. L. BAUSCH
HARTE COOKE
R. H. FERNALD
F. M. GUNBY

Terms expire 1938
L. P. ALFORD
J. L. HARRINGTON
D. C. JACKSON
ROBERT SIBLEY

Terms expire 1940
W. H. CARRIER
E. R. FISH
H. C. MEYER, JR.
L. W. WALLACE

Terms expire 1941
H. A. S. HOWARTH
GEO. A. ORROK
J. W. ROE

Professional Divisions

(*Personnel of Standing Committee, page* RI-1)

Aeronautic Division

Organized, 1920

EXECUTIVE COMMITTEE

ALEXANDER KLEMIN, *Chairman*
CHAS. H. DOLAN, *1st Vice-Chairman*
JEROME LEDERER, *Secretary*
R. M. MOCK
R. V. MORSE
B. M. WOODS

GENERAL COMMITTEE

E. A. SPERRY, *Chairman*
(To be appointed)

COMMITTEE ON INDUSTRIAL AERODYNAMICS

ALEXANDER KLEMIN, *Secretary*
OLIVER ALLEN
W. H. CARRIER
H. E. DAVISON
H. P. FREAR
W. G. GROVE
O. E. HOVEY
A. L. KIMBALL
R. J. S. PIGOTT
L. K. SILLCOX

REPRESENTATIVES ON OTHER ACTIVITIES

Aircraft Safety and Inspection, JEROME LEDERER
Marking of Obstructions to Air Navigation, J. E. WHITBECK
Spirit of St. Louis Medal Board of Award, V. J. AZBE
Daniel Guggenheim Medal Fund, E. E. ALDRIN

Applied Mechanics Division

Organized, 1927

EXECUTIVE COMMITTEE

C. R. SODERBERG, *Chairman*
J. C. HUNSAKER, *Secretary*
J. P. DEN HARTOG
R. EKSERGIAN
B. M. WOODS

Associates

A. L. KIMBALL
G. B. PEGRAM
E. O. WATERS

JOURNAL OF APPLIED MECHANICS

EXECUTIVE COMMITTEE

J. M. LESSELLS, *Technical Editor*
J. P. DEN HARTOG
E. O. WATERS

SUBCOMMITTEE CHAIRMEN

Applied Physics (A.I.P.), G. B. PEGRAM
Elasticity, STEPHEN TIMOSHENKO
Fluid Mechanics, HUGH L. DRYDEN
Hydromechanics, THEODOR VON KÁRMÁN
Institute of Aeronautical Sciences, J. P. DEN HARTOG
Materials, R. E. PETERSON
Plasticity, A. NÁDAI
Thermodynamics, J. A. GOFF
Vibration, F. M. LEWIS

Fuels Division

Organized, 1920

EXECUTIVE COMMITTEE

T. A. MARSH, *Chairman*
A. R. MUMFORD, *Secretary*
L. C. BOSLER
W. G. CHRISTY
H. O. CROFT
M. D. ENGLE

Associates

A. D. BLAKE
K. M. IRWIN
R. A. SHERMAN
A. C. STERN
F. M. VAN DEVENTER

SUBCOMMITTEE ON PROGRAMS, MEETINGS, AND AIMS

W. G. CHRISTY, *Chairman*

COMMITTEE ON SAMPLING PULVERIZED FUEL IN A MOVING GAS STREAM

(Research Committee; see page RI-18)

K. M. IRWIN, *Chairman and Representative of Fuels Division*

COMMITTEE ON REMOVAL OF ASH AS MOLTEN SLAG FROM POWDERED-COAL FURNACES

(Research Committee; see page RI-18)

K. M. Irwin, *Chairman and Representative of Fuels Division*

SUBCOMMITTEE ON SMOKE ABATEMENT LAW

Organizing Committee

W. G. Christy
K. M. Irwin

Graphic Arts Division

Formerly Printing Industries Division. Organized, 1922

EXECUTIVE COMMITTEE

B. D. Stevens, *Chairman*
T. E. Dalton, *Secretary*
Edward Epstean
A. E. Giegengack
R. G. MacDonald
Hadar Ortman

Associates

G. H. Carter
W. C. Glass
W. F. Harvey
W. C. Huebner
W. S. Huson
W. R. Maull
J. C. Oswald

The Division sponsors the Conference of the Technical Experts in the Printing Industry, a forum for the discussion of the mechanical and process problems of the entire graphic arts field; also the Graphic Arts Research Bureau, formed to act as a clearing-house for graphic arts research and for the collection, correlation, and distribution of research information pertaining to the industry and for the sponsorship of research work.

Hydraulic Division

Organized, 1926

EXECUTIVE COMMITTEE

S. Logan Kerr, *Chairman*
F. G. Switzer, *Secretary*
Paul Diserens
C. F. Merriam
Forrest Nagler
M. P. O'Brien

COMMITTEE ON WATER HAMMER

Honorary Member, Lorenzo Allievi, Rome, Italy
S. Logan Kerr, *Sponsor and Chairman*

N. R. Gibson
E. B. Strowger
L. F. Moody
R. S. Quick
Eugene Halmos (A.S.C.E.)

Associate Members

American Water Works Association represented by Frank M. Dawson and Thomas H. Wiggin
Engineering Institute of Canada represented by R. W. Angus and F. M. Wood
Louis Bergeron, France
A. W. K. Billings, Brazil
Charles Camichel, France
Gaudenzio Fantoli, Italy
A. H. Gibson, Great Britain
George Higgins, Australia
Charles Jaeger, Switzerland
F. Knapp, Brazil
R. Loewy, Austria
Albino Pasini, Italy
O. Schnyder, Switzerland
D. Thoma, Germany and V. D. I.

Committee on Cavitation, C. F. Merriam, *Sponsor* (Chairman to be appointed)
Committee on General Hydraulics, M. P. O'Brien, *Sponsor* (Chairman to be appointed)
Committee on Hydraulic Prime Movers, Forrest Nagler, *Sponsor* (Chairman to be appointed)
Committee on Pumping Machinery, Paul Diserens, *Sponsor* (Chairman to be appointed)

Iron and Steel Division

Organized, 1927

EXECUTIVE COMMITTEE

S. M. Weckstein, *Chairman*
Morris Stone, *Secretary*
J. A. Clauss
S. M. Marshall
Willis McKee
T. H. Wickenden

Associates

A. J. Boynton
J. H. Hitchcock
J. H. Romann
G. T. Snyder
W. Trinks
W. R. Webster

Machine Shop Practice Division

Organized, 1921

EXECUTIVE COMMITTEE

G. F. Nordenholt, *Chairman*
J. R. Weaver, *Secretary*
A. N. Goddard
A. M. Johnson
B. G. Tang

SUBCOMMITTEE ON FOUNDRY PRACTICE

James Thomson, *Chairman*
R. E. Kennedy, *Secretary*

SUBCOMMITTEE ON MACHINE DESIGN

E. S. Ault, *Chairman*

SUBCOMMITTEE ON LUBRICATION ENGINEERING

W. F. Parish, *Chairman*
C. H. Bromley
G. B. Karelitz
C. M. Larson
H. J. Masson

SUBCOMMITTEE ON CUTTING METALS

(Research Committee; see page RI-17)

Coleman Sellers, 3rd, *Chairman and Representative of Machine Shop Practice Division*

SUBCOMMITTEE ON WELDING

C. W. Obert, *Chairman*

Management Division

Organized, 1920

EXECUTIVE COMMITTEE

L. C. Morrow, *Chairman*
L. N. Rowley, Jr., *Secretary*
W. H. Kushnick, *Vice-Chairman*
J. A. Jacobs
G. W. Kelsey

Associates

C. W. Lytle
J. A. Piacitelli
F. E. Raymond
J. R. Shea

GENERAL ADVISORY BOARD

W. L. Batt
F. B. Bell
E. P. Bullard
C. I. Day
Norman Elsas
E. W. Farley
E. V. French
W. D. Fuller
Lee Galloway
J. W. Higgins
G. N. Jeppson
W. G. Kranz
G. H. Malcolm
A. W. Morton
J. F. Porter
J. C. Wilson

FUNCTIONAL ADVISORY BOARD

(To be appointed)

LOCAL SECTION REPRESENTATIVES

Chicago, Adolph Langsner
Detroit, W. W. Nichols
New York, A. F. Ernst
Pittsburgh, J. Roy Tanner
Providence, J. G. Aldrich

Materials Handling Division

Organized, 1920

EXECUTIVE COMMITTEE

R. B. Renner, *Chairman*
F. J. Shepard, Jr., *Secretary*
G. E. Hagemann, *Vice-Chairman*
Nixon Elmer
J. A. Jackson
F. E. Moore

Associates

F. D. Campbell
R. H. McLain
E. D. Smith
J. B. Webb

Oil and Gas Power Division

Organized, 1921

EXECUTIVE COMMITTEE

Ernest Nibbs, *Chairman*
M. J. Reed, *Secretary*
F. G. Hechler
Edgar J. Kates
L. H. Morrison
Lee Schneitter

Associates

Carl Behn
Harte Cooke
L. R. Ford
L. M. Goldsmith
H. C. Major
Ralph Miller

SUBCOMMITTEE ON OIL ENGINE POWER COST REPORT FOR 1936

H. C. Major, *Chairman*
M. J. Reed, *Secretary*
Herbert Baxley
Hale Codding
L. R. Ford
E. J. Kates
H. C. Lenfest
A. B. Morgan
H. A. Person
Lee Schneitter
P. H. Schweitzer
H. C. Thuerk
C. A. Trimmer
Patrick Schlesinger

Petroleum Division

Organized, 1925

EXECUTIVE COMMITTEE

W. H. Carson, *Chairman*
T. D. Tifft, *Secretary*
J. H. Englebrecht, *Mid-Continent Secretary*
E. H. Barlow
F. H. Eberle
W. G. Heltzel

Associates

H. F. Brindel
H. P. Porter

Power Division

Organized, 1920

EXECUTIVE COMMITTEE

W. E. Caldwell, *Chairman*
E. L. Hopping, *Secretary*
J. M. Brentlinger
W. A. Carter
G. A. Gaffert
J. C. Hobbs

Process Industries Division

Organized, 1934

EXECUTIVE COMMITTEE

Victor Wichum, *Chairman*
W. K. McAfee, *Vice-Chairman*
T. R. Olive, *Secretary*
C. E. Harrington
John Sengstaken
A. Weisselberg

SUBCOMMITTEE CHAIRMEN

Air Conditioning, Arnold Weisselberg
Brewing, C. F. Kayan
Ceramics, W. K. McAfee
Cottonseed Processing, W. R. Woolrich
Drying, C. W. Thomas
Food Processing, G. L. Montgomery
Industrial Instruments and Regulators, Ed S. Smith
Pulp and Paper, H. D. Fisher
Sanitation, William Raisch
Sugar, F. M. Gibson
Unit Operation Costs, H. J. Masson

HEAT TRANSFER COMMITTEE

J. H. Sengstaken, *Chairman*
W. S. Patterson, *Secretary*
R. E. Birch
Thos. Drew
E. D. Grimison
H. C. Hottel
C. E. Lucke
A. K. Scott
M. S. Van Dusen

Railroad Division

Organized, 1920

EXECUTIVE COMMITTEE

W. H. Winterrowd, *Chairman*
C. T. Ripley, *1st Vice-Chairman*
E. C. Schmidt, *2nd Vice-Chairman*
L. H. Fry, *3rd Vice-Chairman*
A. I. Lipetz, *4th Vice-Chairman*
M. B. Richardson, *Secretary*

GENERAL COMMITTEE (RR2)

W. H. Winterrowd, *Chairman*
D. S. Ellis (1937)
Thos. C. McBride (1937)
K. F. Nystrom (1937)
W. H. Clegg (1938)
F. G. Lister (1938)
G. A. Young (1938)
Harvey Boltwood (1939)
Frank E. Russell (1939)
R. W. Salisbury (1939)
O. C. Cromwell (1940)
W. E. Dunham (1940)
J. R. Jackson (1940)
A. Giesl-Gieslingen (1941)
L. W. Wallace (1941)
E. G. Young (1941)

PAST-CHAIRMEN (RR3)

E. B. Katte * (1920-1922)
James Partington (1923-1924)
C. E. Chambers (1925)
H. B. Oatley (1926-1927)
Wm. Elmer (1928)
R. S. McConnell (1929)
A. F. Steubing (1930)
Eliot Sumner (1931)
T. C. McBride (1932)
L. K. Sillcox (1933)
C. B. Peck (1934)
C. E. Barba (1935)
Geo. W. Rink (1936)

CHICAGO GROUP (RR4)

Peter Parke, *Chairman*
E. L. Woodward, *Secretary*
Walter Dunham
W. O. Moody
C. T. Ripley
W. H. Winterrowd

COMMITTEE ON MEETINGS AND PAPERS (RR5)

W. E. Dunham, *Chairman*
J. R. Jackson

COMMITTEE ON SURVEY (RR6)

A. Giesl-Gieslingen, *Chairman* (Locomotive and Foreign Developments)
W. H. Clegg (Canadian and Automotive Equipment)
K. F. Nystrom (Cars)

COMMITTEE ON RESEARCH (RR9)

A. F. Steubing, *Chairman*
W. G. Dickerman
William Elmer
L. H. Fry
C. B. Peck
L. W. Wallace
W. H. Winterrowd

* Deceased

Textile Division

Organized, 1921

EXECUTIVE COMMITTEE

A. W. Benoit, *Chairman*
H. D. Learnard, *Vice-Chairman*
M. A. Golrick, Jr., *Secretary*
Wendell Brown
R. DeVere Hope
Albert Palmer

Associates

J. J. McElroy
Clifford H. Ramsey
Earl Stall

Wood Industries Division

Organized, 1921

EXECUTIVE COMMITTEE

A. W. Keuffel, *Chairman*
L. M. Nichols, *Secretary*
T. D. Perry
R. H. McCarthy
P. T. Norton, Jr.

Associates

C. L. Babcock
P. H. Bilhuber
H. B. Carpenter
P. P. Cartwright
A. S. Kurkjian
Sern Madsen
J. H. Mansfield
J. S. Mathewson
G. R. Petrie
A. D. Smith

MACHINING OF WOOD COMMITTEE

R. H. McCarthy, *Chairman*
C. L. Babcock
E. M. Davis
G. E. French
W. Kynoch
C. M. Thompson

Student Branches

(*Personnel of Standing Committee on Relations With Colleges, page* RI-2. *Communicate with Student Branch through Honorary Chairman*)

Name and Location	Year Authorized	Chairman	Secretary	Honorary Chairman
Akron, Univ. of, Akron, Ohio	1924	John E. Martin	John Good	Fred S. Griffin
Alabama, Polytechnic Inst., Auburn, Ala.	1920	F. H. Richter	Roy Dodge	C. R. Hixon
Alabama, Univ. of, University, Ala.	1931	D. L. Drake	P. P. Sheaff	J. M. Gallalee
Arkansas, Univ. of, Fayetteville, Ark.	1910	J. M. Brown	J. W. Niven	R. G. Paddock
Armour Inst. of Technology, Chicago, Ill.	1909	S. M. Miner	L. Janas	Daniel Roesch
Brooklyn. Polytechnic Inst. of, Brooklyn, N. Y.	1909	Geo. McFarland	M. J. Zemetra	J. A. Lambertine
Brooklyn. Polytechnic Inst. of, Brooklyn, N. Y. (Evening)		A. N. Stad	J. M. Ihasz	J. A. Lambertine
Brown Univ., Providence, R. I.	1923	H. A. Harrington	E. F. Pickering	Z. R. Bliss
Bucknell Univ., Lewisburg, Pa.	1916	S. A. DeMuro	L. B. Kob	F. E. Burpee
California Inst. of Technology, Pasadena, Calif.	1914	J. C. Kinley	Irving Ashkenas	D. S. Clark
California, Univ. of, Berkeley, Calif.	1912	B. E. DelMar	J. E. Lindberg, Jr.	B. F. Raber
Carnegie Inst. of Technology, Pittsburgh, Pa.	1913	Raymond Reisacher	Bertel Ekholm	T. G. Estep
Case School of Applied Science, Cleveland, Ohio	1913	Allen Stern	W. E. Forbes	G. B. Carson
Catholic Univ. of America, Washington, D. C.	1922	R. K. Slaughter, Jr.	M. J. Clune	M. E. Weschler
Cincinnati, Univ. of, Cincinnati, Ohio	1909	W. E. Berning	R. S. Goebel	R. L. Smith
Clarkson College of Technology, Potsdam, N. Y.	1930	S. F. Cartin	Charles Quentin	J. A. Ross, Jr.
Clemson A. & M. College, Clemson College, S. C.	1920	J. T. Mann	R. L. Geisberg	B. E. Fernow
Colorado State College of Agriculture & Mechanic Arts, Fort Collins, Colo.	1914	H. B. Standley	W. F. Crenshaw	D. P. Craig
Colorado, Univ. of, Boulder, Colo.	1914	David Ware	Donald Risley	G. S. Dobbins
Columbia Univ., New York, N. Y.	1909	William Tessin	C. A. Gongwer	W. A. Johnson
Cooper Union, New York, N. Y.	1920	Cornelius Kirby	A. A. Budde	H. F. Roemmele
Cornell Univ., Ithaca, N. Y.	1908	John Schadler, Jr.	Gerald Philipp	F. O. Ellenwood
Delaware, Univ. of, Newark, Del.	1929	W. K. Benson, Jr.	E. S. Lomax	Leo Blumberg
Detroit, Univ. of. Detroit, Mich.	1930	R. J. Moore	E. W. Connolly	H. E. Mayrose
Drexel Inst., Philadelphia, Pa.	1920	A. E. Juram	Edward Berry	J. H. Billings
Duke Univ., Durham, N. C.	1935	S. F. Boyce	R. D. Martin	R. S. Wilbur
Florida, Univ. of, Gainesville, Fla.	1926	W. H. Toske	C. D. Mason	N. C. Ebaugh
George Washington Univ., Washington, D. C.	1924	C. J. Mikuszewski	R. P. Strout	B. C. Cruickshanks
Georgia School of Technology, Atlanta, Ga.	1915	H. D. Emmert, Jr.	A. A. Miller	R. A. Trotter
Idaho, Univ. of, Moscow, Idaho	1925	Jos. Gauss	Walfred Carlson	H. F. Gauss
Illinois. Univ. of, Urbana, Ill.	1909	G. H. Logan	E. J. Wellman	F. H. Thomas
Iowa State College, Ames, Iowa	1919	J. B. Codlin	R. D. Rae	Harry Daasch
Iowa, State Univ. of, Iowa City, Iowa	1913	D. G. Schaefer	Everett Waters	R. M. Barnes
Johns Hopkins Univ., Baltimore, Md.	1917	Wallace MacWilliams, Jr.	R. E. Nopper	F. W. Kouwenhoven
Kansas State College, Manhattan, Kan.	1914	C. T. Thompson	J. M. Kliewer	Linn Helander
Kansas, Univ. of, Lawrence, Kan.	1909	R. A. Russell	Lemoin Votaw	A. H. Sluss
Kentucky, Univ. of, Lexington, Ky.	1911	Thomas Harmon	N. I. Gebhart	R. C. Porter
Lafayette College, Easton, Pa.	1919	E. M. Breen	J. F. Young	C. M. Merrick, III
Lehigh Univ., Bethlehem, Pa.	1911	W. H. Shank	R. P. Sturgis	B. H. Jennings
Lewis Inst., Chicago, Ill.	1933	William Cramer	Fred Taylor	V. L. Sherman
Louisiana State Univ., Baton Rouge, La.	1916	Ferd Kramer	L. T. Weathers	William Whipple
Louisville, Univ. of, Louisville, Ky.	1928	Kenneth Hess	G. E. Wuest	R. S. Trosper
Maine, Univ. of, Orono, Maine	1910	G. S. Williams, Jr.	C. F. Golding	W. J. Sweetser
Marquette Univ., Milwaukee, Wis.	1923	C. H. Krause	W. H. Losse	J. E. Schoen
Massachusetts Inst. of Technology, Cambridge, Mass.	1909	W. H. Austin	J. B. Nugent	C. L. Svenson
Michigan College of Mining & Technology, Houghton, Mich.	1930	A. B. Johnson	Harrison Weaver	H. W. Risteen
Michigan State College, E. Lansing, Mich.	1917	A. E. LaRocque	D. R. Wilson	H. B. Dirks

Name and Location	Year Authorized	Chairman	Secretary	Honorary Chairman
Michigan, Univ. of, Ann Arbor, Mich.	1914	J. F. Ingold	E. L. Sinclair	H. E. Keeler
Minnesota, Univ. of, Minneapolis, Minn.	1913	Gerry Mitchell	Karl Haugen	J. J. Ryan
Mississippi State College, State College, Miss.	1926	H. V. Cooper, Jr.	J. F. Williamson	R. C. Carpenter
Missouri School of Mines and Metallurgy, Rolla, Mo.	1930	R. R. Kaley	W. E. Luder	R. O. Jackson
Missouri, Univ. of, Columbia, Mo.	1909	J. A. Martin	C. C. Holt	J. R. Wharton
Montana State College, Bozeman, Mont.	1920	Jack Boetcher	David Cochrane	M. R. Good
Nebraska, Univ. of, Lincoln, Neb.	1909	J. E. Passmore	P. J. Gamlin	A. A. Luebs
Nevada, Univ. of, Reno, Nev.	1923	Guy Morris	Vernon Scott	F. H. Sibley
Newark College of Engineering, Newark, N. J.	1924	J. T. Bailey	R. D. Weigand	F. D. Carvin
New Hampshire, Univ. of, Durham, N. H.	1926	A. M. Weatherby	S. E. Tomkinson	J. J. Uicker
New Mexico, Univ. of, Albuquerque, New Mex.	1935	Howard Benischek	Dalton Bergan	M. E. Farris
New York, College of the City of, New York, N. Y.	1922	Alfred Dietrich	Michael Friedman	G. J. Bischof
New York Univ., New York, N. Y., Mechanical Division	1917	Zygmont Jaros	Gerard Russo	A. C. Coonradt
New York Univ., New York, N. Y., Aeronautic Division	1917	Robert Lehr	R. S. Buck	F. K. Teichmann *
New York Univ., New York, N. Y., Evening Branch	1933	Adolph Panitz	J. E. Darlington	A. C. Coonradt
North Carolina State College, Raleigh, N. C.	1920	F. L. Connell	E. L. Guerrant	L. L. Vaughan
North Carolina, Univ. of, Chapel Hill, N. C.	1929	W. P. Kephart	H. E. Robbins, Jr.	E. G. Hoeffer
North Dakota Agricultural College, Fargo, N. D.	1929	Earl Martinson	Earl Vollrath	R. M. Dolve
North Dakota, Univ. of, Grand Forks, N. D.	1923	M. E. Aiegenhagen	Glendon Barrows	Orvie Highum
Northeastern Univ., Boston, Mass.	1922	H. C. Wilder (Div. A) P. D. Johnson (Div. B)	G. A. Reed, Jr. (Div. A) A. C. Beck (Div. B)	J. W. Zeller (Divs. A and B)
Northwestern Univ., Evanston, Ill.	1935	Ray Tegtmeyer	John Wahlstrom	H. S. Philbrick
Notre Dame, Univ. of, Notre Dame, Ind.	1929	B. F. Hartz	J. A. Riley	C. C. Wilcox
Ohio Northern Univ., Ada, Ohio	1922	R. H. Leisenheimer	E. I. Salo	J. A. Needy
Ohio State Univ., Columbus, Ohio	1911	P. G. Haywood	J. H. Eagle	S. R. Beitler
Oklahoma A. & M. College, Stillwater, Okla.	1921	Vane Brant	Edward Dunning	V. W. Young
Oklahoma, Univ. of, Norman, Okla.	1917	Marion Dorney	William Allen	E. E. Ambrosius
Oregon State Agricultural College, Corvallis, Ore.	1909	J. A. Montgomery	S. R. Kelley	J. C. Othus
Pennsylvania State College, State College, Pa.	1909	A. M. Krakower	H. N. Taylor	C. L. Allen
Pennsylvania, Univ. of, Philadelphia, Pa.	1925	John Doering	Herbert Bernstein	C. H. Coogan, Jr.
Pittsburgh, Univ. of, Pittsburgh, Pa.	1917	A. A. Gradisar	J. B. Wood	S. J. Tracy, Jr.
Pratt Inst., Brooklyn, N. Y.	1923	W. A. Freer	F. W. Fiala	R. B. Dale
Princeton Univ., Princeton, N. J.	1926	M. C. Long	C. W. Williams	A. M. Greene, Jr.
Puerto Rico, Univ. of, Mayaguez, P. R.	1923			R. I. Gil
Purdue Univ., W. Lafayette, Ind.	1909	R. K. Weldy	W. B. Wolverton	L. V. Ludy
Rensselaer Polytechnic Inst., Troy, N. Y.	1910	J. B. Nolan	H. D. Herbert, Jr.	E. A. Fessenden
Rhode Island State College, Kingston, R. I.	1930	E. G. Mills	R. W. Warren	R. L. Wales
Rice Inst., Houston, Tex.	1925	Edward Boyle	H. B. Young	A. H. Burr
Rose Polytechnic Inst., Terre Haute, Ind.	1926	Clyde Cromwell	Frank Blount	Carl Wischmeyer
Rutgers Univ., New Brunswick, N. J.	1920	Robert Burns	F. C. Erhart	N. P. Bailey
Santa Clara, Univ. of, Santa Clara, Calif.	1925	W. J. Adams, Jr.	F. P. Gomes	G. L. Sullivan
South Dakota State College, Brookings, S. D.	1935	Anders Lyngstad	Robt. Bentson	J. T. Strate
Southern California, Univ. of, Los Angeles, Calif.	1929	Roderick Keenan	Elmer Solomonson	T. T. Eyre
Southern Methodist Univ., Dallas, Tex.	1933	Werner Henke	Sam Shook	R. E. Lewis
Stanford Univ., Stanford University, Calif.	1909	S. E. Weaver, Jr.	H. B. Munton	A. B. Domonoske
Stevens Inst. of Technology, Hoboken, N. J.	1908	R. L. Buchanan	R. S. Phair	J. I. Yellott, Jr.
Swarthmore College, Swarthmore, Pa.	1921	John H. Beck		G. B. Thom
Syracuse Univ., Syracuse, N. Y.	1912	R. C. Stumpf	F. D. Weeks	A. R. Acheson
Tennessee, Univ. of, Knoxville, Tenn.	1923	R. M. Russell, Jr.	C. K. Norris	F. L. Wilkinson
Texas, A. & M. College of, College Sta., Tex.	1921	W. W. Harris	Richard White	V. M. Faires
Texas Technological College, Lubbock, Tex.	1930	A. R. Cooper	Henry Meredith	H. F. Godeke
Texas, Univ. of, Austin, Tex.	1921	P. B. Croom	R. L. Rather	B. E. Short
Toronto, Univ. of, Toronto, Ont., Can.	1933	M. F. Carriers	A. S. Forman	W. G. McIntosh
Tufts College, Tufts College, Mass.	1917	R. W. Hunt	James Little	C. H. Chase
Tulane Univ., New Orleans, La.	1933	H. W. Blakeslee	R. B. James	J. K. Mayer
Utah, Univ. of, Salt Lake City, Utah	1923	B. D. Hatch	Lawrence Sentker	W. J. Cope
U. S. Naval Academy, Post Graduate School, Annapolis, Md.	1925			P. J. Kiefer
Vanderbilt Univ., Nashville, Tenn.	1928	E. C. Hughes	George Brengelman	S. H. Acker
Vermont, Univ. of, Burlington, Vt.	1922	F. H. Truax	D. R. Leekoff	E. L. Sussdorff
Villanova College, Villanova, Pa.	1925	Joseph Delaney	E. A. Mathias	J. S. Morehouse
Virginia Polytechnic Inst., Blacksburg, Va.	1915	C. D. Richards	R. G. Gibbs	J. B. Jones
Virginia, Univ. of, University, Va.	1923	P. F. Hurt	J. T. Calhoun	A. F. Macconochie
Washington, State College of, Pullman, Wash.	1930	Everett Hanson	William Cartwright	E. B. Parker
Washington, Univ. of, Seattle, Wash.	1917	Robert Foster	George Lundstrom	B. T. McMinn
Washington Univ., St. Louis, Mo.	1911	Eugene Hail	Orville Miller	E. H. Sager
West Virginia Univ., Morgantown, W. Va.	1922	G. M. Kyle	B. L. Park	L. L. Amidon
Wisconsin, Univ. of, Madison, Wis.	1909	Eugene Kirtland	W. F. Gother	T. P. Colbert
Worcester Polytechnic Inst., Worcester, Mass.	1914	A. H. Johnson	W. G. Richards	D. G. Downing
Wyoming, Univ. of, Laramie, Wyo.	1925	Kelly Niederjohn	William Greever	S. P. Hunt
Yale Univ., New Haven, Conn.	1910	C. S. Edgar	J. B. Packer, Jr.	S. W. Dudley

* *Faculty Advisor.*

Local Sections

(Personnel of Standing Committee, p. RI-1)

Mid-West Office

Room 1617, 205 West Wacker Drive, Chicago, Ill.

Mid-Continent Office

J. H. Engelbrecht, Mid-Continent Petroleum Secretary, 102 Tulsa Bldg., Tulsa, Okla.

Regional Group Delegates to Annual Conferences

Terms expire October, 1937

W. L. Edel, Group I
Theo. Baumeister, Jr., Group II
R. S. Brescka, Group III
S. B. Earle, Group IV
S. R. Beitler, Group V
R. M. Barnes, Group VI
D. R. Gray, Group VII

Terms expire October, 1938

J. P. Harbeson, Jr., *Speaker*, Group III
V. M. Frost, *Secretary*, Group II
A. L. Davis, Group I
L. J. Lassalle, Group IV
K. F. Treschow, Group V
C. A. Koepke, Group VI
E. O. Eastwood, Group VII

AKRON-CANTON

Organized: 1920
Territory: Counties of Richland, Ashland, Medina, Summit, Portage, Wayne, Stark, Holmes, Tuscarawas, Carroll, and Coshocton in Ohio
Number of Members: 123

Executive Committee

H. A. Trishman, *Chairman*
W. P. Cox, *Vice-Chairman*
James Forrest, *Secretary-Treasurer*
M. R. Bowerman
W. O. Clinedinst
E. C. Huge
E. F. Maas
R. H. Smith
H. E. Waner
C. D. Zimmerman

ANTHRACITE-LEHIGH VALLEY

Organized: 1920, as Lehigh Valley; reorganized, 1928, as Anthracite-Lehigh Valley
Territory: Counties of Bradford, Susquehanna, Wayne, Sullivan, Wyoming, Lackawanna, Columbia, Luzerne, Monroe, Pike, Schuylkill, Carbon, Berks, Lehigh, Northampton in Pennsylvania, and Warren in New Jersey
Place of Meeting: One meeting annually at Allentown, Bethlehem, Easton, Hazleton, Pottsville, Reading, Scranton, and Wilkes-Barre
Local Organization: The Engineers' Club of Lehigh Valley
Number of Members: 185

Executive Committee

P. B. Eaton, *Chairman*
F. H. Dechant, *Vice-Chairman*
H. A. Pickel, *Vice-Chairman*
C. W. Bell, *Secretary*
R. J. Prince, *Treasurer*
R. D. Berniger
A. B. Clemens
E. M. Fernald
W. W. Hagerty
C. H. McKnight
R. H. Porter
J. T. Rea
W. P. Saunier
J. W. Steinmeyer

ATLANTA

Organized: 1913
Territory: Radius of sixty miles from Atlanta, Ga.
Place of Meeting: Atlanta Athletic Club
Luncheon meeting every Monday at 12:30 P. M. at Atlanta Athletic Club
Number of Members: 69

Executive Committee

G. Braungart, Jr., *Chairman*
R. M. Matson, *Vice-Chairman*
M. F. Merl, *Secretary-Treasurer*
T. E. Bell
H. D. Emmert
S. C. Hale
R. Whitfield

BALTIMORE

Organized: 1916
Territory: Radius of thirty miles from Baltimore, Md.
Place of Meeting: Engineers' Club of Baltimore
Luncheon meeting every Wednesday at 12:00 noon at Engineers' Club
Number of Members: 144

Executive Committee

R. C. Dannettel, *Chairman*
K. P. Hanson, *Secretary-Treasurer*
C. R. Chisholm
L. F. Coffin
N. B. Higgins
J. C. Holtz
F. W. Kouwenhoven
A. L. Penniman
W. E. Proctor

BIRMINGHAM

Organized: 1915
Territory: Radius of sixty miles from Birmingham, Ala.
Place of Meeting: Tutwiler Hotel
Number of Members: 59

Executive Committee

T. J. Carpenter, *Chairman*
G. R. Ozley, *Vice-Chairman*
D. H. Guldberg, *Secretary-Treasurer*
Neal Dugger
J. W. Eshelman

BOSTON

Organized: 1909
Territory: Radius of thirty miles from Boston, Mass.
Place of Meeting: Rooms of the Engineering Societies of New England
Local Organization: Engineering Societies of New England
Number of Members: 521

Executive Committee

George Eaton, *Chairman*
E. L. Root, *Vice-Chairman*
B. B. Fogler, *Secretary*
H. K. Dean
James Holt
G. F. Jenks

BRIDGEPORT

Organized: 1917, as a Branch of Connecticut Section; reorganized as a Section, 1923
Territory: Fairfield County, Conn.
Place of Meeting: Stratfield Hotel
Local Organization: Engineers' Club of Bridgeport
Number of Members: 127

Executive Committee

C. N. Hoagland, *Chairman*
O. J. Richmond, *Vice-Chairman*
W. H. Sniffen, *Secretary*
A. W. Hagan, *Treasurer*
T. H. Beard
J. Brenzinger
Arthur Brewer
W. R. Clark
A. H. Emery
H. Patterson Harris
R. C. Moody
H. E. Wells

BUFFALO

Organized: 1915
Territory: Radius of thirty miles from Buffalo, N. Y.
Place of Meeting: Hotel Statler
Local Organization: Engineering Society of Buffalo
Number of Members: 166

Executive Committee

J. L. Yates, *Chairman*
Paul Dubosclard, *Vice-Chairman*
W. A. Miller, *Secretary*
C. E. Harrington, *Treasurer*
Carl Rosa
W. M. Kauffman
E. K. Nicholson

CENTRAL INDIANA

Organized: 1916
Territory: Radius of eighty miles from Indianapolis, within Indiana
Place of Meeting: Place varies
Local Organization: Indiana Engineering Society
Number of Members: 112

Executive Committee

F. C. Hockema, *Chairman*
F. R. Weaver, *Vice-Chairman*
J. C. Siegesmund, *Secretary-Treasurer*
James Cunning
Homer Rupard

CENTRAL PENNSYLVANIA

Organized: 1921
Territory: Radius of approximately sixty miles from State College, Pa.
Place of Meeting: Pennsylvania State College, State College, Pa.
Number of Members: 82

Executive Committee

C. H. Kent, *Chairman*
F. Stewart, *Secretary*
H. A. Everett
John Henzey

CHARLOTTE

Organized: As a Branch, 1923; as a Section, 1927
Territory: Radius of seventy-five miles from Charlotte, N. C.
Luncheon Meeting every Monday at 1:00 P.M. at Efirds Department Store
Number of Members: 35

Executive Committee

W. E. McDowell, *Chairman*
V. E. Fuller, *Vice-Chairman*
W. W. Leroy, *Secretary-Treasurer*
Asa Hosmer
R. W. Olive

CHATTANOOGA

Organized: 1922
Territory: Radius of sixty miles from Chattanooga, Tenn.
Local Organization: Chattanooga Engineers' Club
Luncheon meeting every Monday noon at Chattanooga Engineers' Club
Number of Members: 15

Executive Committee

Newell Sanders, *Chairman*
H. H. Bailey, *Vice-Chairman*
F. Ward Reilly, *Secretary-Treasurer*
L. G. Haller
M. P. Wall

CHICAGO

Organized: 1913
Territory: Radius of fifty miles from Chicago, Ill.
Headquarters: Mid-West A.S.M.E. Office, Room 1617, 205 West Wacker Drive, Chicago, Ill.
Luncheon Meeting every Tuesday at 12:15 P. M. at Chicago Engineers' Club
Local Organization: Western Society of Engineers
Number of Members: 698

Executive Committee

T. S. McEwan, *Chairman*
W. E. Dunham, *Vice-Chairman*
F. B. Orr, *Secretary-Treasurer*
R. D. Brizzolara
C. B. Cole
L. A. Clousing
Hugo Diemer
Nixon Elmer
J. S. Kozacka
F. H. Lane
Adolph Langsner
C. T. Link, Jr.
D. Roesch
Edward R. Rowley
R. E. Turner
W. H. Winterrowd
E. L. Woodward

CINCINNATI

Organized: 1912
Territory: Radius of thirty miles from Cincinnati, Ohio
Place of Meeting: Engineers' Club Rooms, Ninth & Race Sts.
Local Organization: Engineers' Club of Cincinnati
Number of Members: 177

Executive Committee

F. E. Cardullo, *Chairman*
H. C. Uihlein, *Vice-Chairman*
C. A. Joerger, *Secretary-Treasurer*
D. Brown
W. E. M. Fielman
C. L. Koehler
Edward Martin
L. F. Nenninger
R. S. Parker
F. H. Pfefferle

CLEVELAND

Organized: 1918
Territory: Counties of Lorain, Cuyahoga Lake, Geauga, and Ashtabula in Ohio
Place of Meeting: Statler Hotel
Local Organization: Cleveland Engineering Society
Luncheon Meeting every Wednesday at 12:30 P. M. at Hotel Statler Cafeteria
Number of Members: 250

Executive Committee

E. Stanley Ault, *Chairman*
F. Jehle, *Vice-Chairman*
E. R. McCarthy, *Secretary*
C. C. McClelland, *Treasurer*
J. Roland Brown
W. C. Connelly
C. A. Dauber
McRea Parker
C. C. Wales

COLORADO

Organized: 1919
Territory: Entire State of Colorado
Place of Meeting: Parisienne Rotisserie Inn, Denver, Colo.
Local Organization: Colorado Engineering Council (Colorado Society of Engineers)
Number of Members: 95

Executive Committee

R. W. Morton, *Chairman*
A. L. Hill, *Secretary-Treasurer*
L. D. Crain
J. A. Hunter
F. A. Lockwood
F. H. Prouty
G. A. Richter

COLUMBUS

Organized: 1920
Territory: Counties of Union, Delaware, Licking, Madison, Franklin, Fayette, Pickaway, and Ross in Ohio
Place of Meeting: Battelle Memorial Institute and Ohio State University
Local Organization: Engineers' Club of Columbus
Luncheon Meeting Third Friday of each month at 12:00 noon at Engineers' Club, Columbus
Number of Members: 74

Executive Committee

R. A. Sherman, *Chairman*
R. C. Cross, *Secretary-Treasurer*
S. R. Beitler
D. R. Croft
H. S. Dickerson
E. M. Sampson
W. A. Welcker, Jr.

DAYTON

Organized: 1926
Territory: Counties of Drake, Miami, Champaign, Preble, Montgomery, Greene, and northern part of Butler and Warren in Ohio
Place of Meeting: Engineers' Club of Dayton
Local Organization: Engineers' Club of Dayton
Number of Members: 75

Executive Committee

R. W. Martin, *Chairman*
G. A. Buvinger, *Vice-Chairman*
J. J. Healy, *Secretary*
B. E. Tate, Jr., *Treasurer*
R. K. Coppock
H. M. Gano
L. E. Hutsel
F. H. Williams

DETROIT

Organized: 1916
Territory: Radius of thirty miles from Detroit, Mich.
Place of Meeting: Place varies
Local Organization: Engineering Society of Detroit
Number of Members: 404

Executive Committee

L. T. Knocke, *Chairman*
C. J. Freund, *Secretary-Treasurer*
C. R. Alden
J. W. Armour
M. W. Benjamin
G. C. Daniels
C. L. Eksergian
J. J. Grebe
H. E. Keeler
A. F. Knoblock
E. T. Vincent
Sabin Crocker, *Ex-Officio*

ERIE

Organized: 1917
Territory: Radius of thirty miles from Erie, Pa.
Place of Meeting: Auditorium of Pennsylvania Telephone Company
Number of Members: 61

Executive Committee

B. S. Cain, *Chairman*
W. L. Hunter, *Vice-Chairman*
E. C. Ims, *Secretary*
C. T. Orgel, *Treasurer*
G. W. Bach
E. R. Gnade
G. Kaemmerling
H. G. Mueller
A. J. Woodward

FLORIDA

Organized: 1925
Territory: State of Florida
Place of Meeting: Place varies
Local Organization: Florida Engineering Society, Gainesville, Fla.
Number of Members: 75

Executive Committee

J. P. Warren, *Chairman*
B. R. Van Leer, *1st Vice-Chairman*
H. J. B. Scharnberg, *2nd Vice-Chairman*
N. C. Ebaugh, *Secretary-Treasurer*
C. Beensen
C. H. Bolton, Jr.
C. V. Imeson
C. M. Lowry
Erling Riis
W. H. Toske

GREEN MOUNTAIN

Organized: 1923
Territory: Entire State of Vermont and neighboring and closely related communities of Claremont and Hanover, N. H.
Place of Meeting: Springfield, Windsor, Vt., and Claremont, N. H.
Local Organization: Vermont Engineering Society
Number of Members: 34

Executive Committee

C. J. Dewell, *Chairman*
M. H. Arms, *Secretary-Treasurer*
C. H. Adams
C. S. Beach
R. W. Haskel
J. B. Johnson
F. A. Joy
H. J. Lockwood
E. L. Sussdorff

GREENVILLE

Organized: As a Branch, 1923; as a Section, 1927
Territory: Radius of sixty miles from Greenville, S. C.
Place of Meeting: Meetings held at Greenville, Clemson College, S. C., Canton, Asheville, and Enka, N. C.
Number of Members: 41

Executive Committee

R. S. Pruitt, *Chairman*
J. A. McPherson, *Vice-Chairman*
J. B. Mayo, *Secretary-Treasurer*
B. E. Fernow
H. H. Iler
G. R. Morgan
E. R. Stall
F. A. Wayant

HARTFORD

Organized: 1917, as Branch of Conn. Section; reorganized, 1923
Territory: Hartford County except that portion served by Meriden and New Britain Sections
Place of Meeting: Hartford Electric Light Company
Number of Members: 115

Executive Committee

E. P. Herrick, *Chairman*
G. R. Truedsson, *Vice-Chairman*
D. K. Morgan, *Secretary-Treasurer*
R. F. Dow
F. O. Hoagland
R. D. Keller
W. S. Paine
R. S. Shaw
S. Jay Teller
H. B. VanZelm
J. C. Ward, Jr.

INLAND EMPIRE

Organized: 1921
Territory: East of Columbia River in State of Washington, and Counties of Okanogan and Benton, and part of Northern Idaho
Place of Meeting: Davenport Hotel, Spokane
Luncheons Wednesdays at 12:00 noon, Davenport Hotel, Spokane
Local Organization: Associated Engineers of Spokane
Number of Members: 26

Executive Committee

H. H. Langdon, *Chairman*
Henry Gauss, *Vice-Chairman*
C. I. Carpenter, *Secretary-Treasurer*
D. R. Gray
L. J. Pospisil

ITHACA

Organized: 1936. Organizing Officer: F. G. Switzer

KANSAS CITY

Organized: 1921
Territory: Radius of sixty miles from Kansas City, Mo.
Place of Meeting: President Hotel
Local Organization: Engineers' Club of Kansas City
Number of Members: 105

Executive Committee

H. A. Smith, *Chairman*
L. Helander, *Vice-Chairman*
H. L. Crain, *Secretary*
W. B. Rollins, *Treasurer*
J. A. King
W. L. Mathews
J. F. Pritchard
J. R. Stone
H. W. Williamson

KNOXVILLE

Organized: 1923
Territory: All the counties east of the west boundaries of the following: Morgan, Roane, Loudon, McMinn, Scott, and Polk, Tenn., and Bell County, Ky.
Place of Meeting: Andrew Johnson Hotel
Local Organization: Knoxville Technical Club
Number of Members: 68

Executive Committee

John Callan, *Chairman*
F. L. Wilkinson, *Vice-Chairman*
R. Brooks Taylor, *Secretary-Treasurer*
C. Daniels
J. M. Kaderly
T. I. Stephenson

LOS ANGELES

Organized: 1915
Territory: South of southern boundaries of following counties: Monterey, Kings, Tulares, and Inyo, Calif.
Place of Meeting: Ninth floor, Chamber of Commerce Bldg.
Local Organization: Technical Societies of Los Angeles
Luncheon Meetings Thursdays at 12:00 noon at Engineers' Club
Number of Members: 374

Executive Committee

H. L. Eggleston, *Chairman*
S. W. Duncan, *Vice-Chairman*
S. M. Dunn, *Secretary-Treasurer*
R. McC. Beanfield
F. M. Beeson
C. W. Coberly
H. S. Ingham

LOUISVILLE

Organized: 1922
Territory: Radius of thirty miles from Louisville, Ky.
Place of Meeting: Engineers' and Architects Club of Louisville
Local Organization: Engineers' and Architects Club
Number of Members: 44

Executive Committee

J. H. Romann, *Chairman*
L. R. Jackson, *Vice-Chairman*
H. H. Fenwick, *Secretary-Treasurer*
B. M. Brigman
G. W. Hubley
John F. Hurst

MEMPHIS

Organized: 1923
Territory: Radius of sixty miles from Memphis, Tenn.
Number of Members: 20

Executive Committee

M. W. Rice, *Chairman*
W. J. Fransioli, Jr., *Secretary-Treasurer*
D. F. Brooks
W. Roberts
M. D. Rust

MERIDEN

Organized: 1917, as a Branch of Connecticut Section; reorganized as a Section, 1923
Territory: Meriden, Middletown, Southington, Portland, Plantsville, and Wallingford, Conn.
Place of Meeting: State Trade School Auditorium
Number of Members: 13

Executive Committee

C. A. Newton, *Chairman*
R. W. Stetson, *Secretary-Treasurer*
E. L. Barker
J. A. Hutchinson
L. B. Marcy
E. A. Robinson
Philip Tripoli
J. C. Tucker

METROPOLITAN

Organized: 1910
Territory: Metropolitan District, New York and New Jersey
Place of Meeting: Engineering Societies Building, New York, N. Y.
Number of Members: 3426

Executive Committee

T. Baumeister, Jr., *Chairman*
C. A. Hescheles, *Secretary*
V. M. Frost, *Treasurer*
J. M. Driscoll
A. Ernst
W. C. Glass
John Hoffhine
T. E. Keating
G. W. Kelsey
J. N. Landis, *Ex-Officio*

MID-CONTINENT

Organized: 1919
Territory: Entire states of Oklahoma and Arkansas, and a part of Louisiana. In Texas north of the southern boundaries of the counties of Gaines, Dawson, Bordon, Scurry, Fisher, Jones, and Shackelford
Place of Meeting: 102 Tulsa Bldg., Tulsa, Okla.
Number of Members: 124

Executive Committee

R. G. Ayers, *Chairman*
J. H. Keyes, *Vice-Chairman*
E. Kemler, *Secretary*
C. H. Keplinger, *Treasurer*
A. J. Mack
B. Oakland
L. C. Price
W. H. Stueve

MILWAUKEE

Organized: 1904
Territory: Radius of fifty miles from Milwaukee, Wis.
Place of Meeting: Milwaukee Athletic Club
Local Organization: Engineers' Society of Milwaukee
Number of Members: 190

Executive Committee

L. H. Stark, *Chairman*
T. F. Eserkaln, *Secretary*
W. D. Bliss
H. Dahlstrand
Fred Dorner
A. H. Luedicke
Arthur Simon

MINNESOTA

Organized: Minneapolis, 1913; St. Paul, 1913; the two Sections merged, 1934
Territory: Entire State of Minnesota
Place of Meeting: Minnesota Union
Local Organization: Minneapolis Engineers' Club, Minnesota Federation of Architectural and Engineering Societies
Number of Members: 86

Executive Committee

L. A. Cobb, *Chairman*
C. A. Koepke, *Vice-Chairman*
A. R. Ford, *Secretary-Treasurer*
George Endicott
Melvin Ovestrud
Harold Washburn

NEBRASKA

Organized: 1922
Territory: State of Nebraska, and Council Bluffs, Iowa
Place of Meeting: Lincoln and Omaha
Local Organization: Engineers' Club of Lincoln and Omaha
Luncheon Meeting every Wednesday noon at the Omaha Engineers' Club
Number of Members: 32

Executive Committee

C. F. Moulton, *Chairman*
A. E. Bunting, *Vice-Chairman*
A. A. Luebs, *Secretary-Treasurer*
W. L. DeBaufre
Otto Jabelmann
L. J. Ruf

NEW BRITAIN

Organized: 1921, as a Branch of Connecticut Section; reorganized as a Section, 1923
Territory: New Britain, Plainville, Forestville, Bristol, Kensington, and Berlin, Conn.
Place of Meeting: Auditorium of the State Trade School
Number of Members: 39

Executive Committee

P. W. Bauer, *Chairman*
C. C. Stevens, *Vice-Chairman*
H. L. Potter, *Secretary-Treasurer*
R. A. Grise
N. F. Hjerpe
B. S. Lewis
C. W. Lund
A. R. Spicacci

NEW HAVEN

Organized: 1912; reorganized, 1923
Territory: Portions of New Haven and Middlesex Counties, Conn.
Place of Meeting: Mason Laboratory, Yale University
Number of Members: 75

Executive Committee

H. R. Polleys, *Chairman*
M. J. Radecki, *Secretary-Treasurer*
Albert F. Breitenstein
F. W. Keator
R. A. North
W. F. Thompson
L. H. Von Ohlsen

NEW ORLEANS

Organized: 1916
Territory: All of Louisiana except the northern part allotted to Mid-Continent Section
Place of Meeting: Room 422, St. Charles Hotel
Local Organization: Louisiana Engineering Society
Number of Members: 88

Executive Committee

C. C. Crawford, *Chairman*
L. J. Lassalle, *Vice-Chairman*
G. R. Hammett, *Secretary-Treasurer*
J. S. Huey
R. F. Muller

NORTH TEXAS

Organized: 1922
Territory: Radius of one hundred and twenty-five miles from Dallas, in Texas
Place of Meeting: Dallas Power & Light Co. Bldg.
Local Organization: Technical Club of Dallas
Number of Members: 80

Executive Committee

R. R. Crowdus, *Chairman*
H. R. Pearson, *Secretary*
E. W. Burbank
P. M. Cordell
J. A. Noyes
H. M. Robinson

NORWICH

Organized: 1930
Territory: Counties of Tolland, Windham, and New London in Connecticut, and Westerly District in Rhode Island
Place of Meeting: Arcanum Club, 150 Main St., Norwich
Number of Members: 33

Executive Committee

C. W. Phelps, *Chairman*
W. E. Beaney, *Secretary-Treasurer*
C. E. Barber
A. E. Welch
L. E. Whiton
W. L. Edel, *Ex-Officio*

ONTARIO

Organized: 1917
Territory: Province of Ontario, Canada
Place of Meeting: Mining Building, University of Toronto
Number of Members: 112

Executive Committee

W. S. Ball, *Chairman*
F. G. East, *Secretary-Treasurer*
T. C. Agnew
J. R. Burgess
C. H. McL. Burns
C. C. Cariss
S. G. Clarke
F. H. Eland
O. W. Ellis
W. G. McIntosh
W. A. Richards
P. G. Welford

OREGON

Organized: 1919
Territory: State of Oregon and that territory in Washington within a radius of thirty miles from Portland, Ore.
Place of Meeting: Portland Hotel, Portland, Ore.
Local Organization: Oregon Society of Engineers
Number of Members: 56

Executive Committee

Paul Heslop, *Chairman*
Rodney Dunlop, *Secretary*
Wm. Brennan
G. O. Matter
J. C. Othus

PENINSULA

Organized: 1923
Territory: West of the east boundaries of the following counties: Emmet, Charlevoix, Antrim, Kalkaska, Missaukee, Clare, Isabella, Gratiot, Clinton, Eaton, Calhoun, and Branch, Mich.
Place of Meeting: Grand Rapids, Mich.
Local Organization: Engineers' Club of Grand Rapids
Number of Members: 39

Executive Committee

C. B. Norris, *Chairman*
L. A. Cornelius, *Vice-Chairman*
R. E. Klise, *Secretary-Treasurer*
Le Roy L. Benedict
A. Kurkjian

PHILADELPHIA

Organized: 1912
Territory: Counties of Bucks, Montgomery, Chester, Philadelphia, Delaware, Pa., and the State of Delaware
Place of Meeting: Philadelphia Engineers' Club, 1317 Spruce Street, Philadelphia, Pa.
Local Organization: Philadelphia Engineers' Club
Luncheon Meeting every Tuesday noon at Philadelphia Engineers' Club
Number of Members: 825

Executive Committee

J. P. Harbeson, Jr., *Chairman*
Coleman Sellers, 3rd, *Vice-Chairman*
C. C. Jones, *Secretary-Treasurer*
H. E. Corl
E. L. Hopping
W. F. Oberhuber

PITTSBURGH

Organized: 1920
Territory: Counties bounded by and including Beaver, Butler, Venango, Forest, Jefferson, Indiana, Somerset, Fayette, Greene, and Washington, Pa.
Place of Meeting: Engineers' Society of Western Pennsylvania, William Penn Hotel
Local Organization: Engineers' Society of Western Pennsylvania
Number of Members: 327

Executive Committee

H. E. Haller, *Chairman*
K. F. Treschow, *Secretary-Treasurer*
H. C. Clausen
G. E. Dignan
G. P. Ellis
J. A. Hunter

PLAINFIELD

Organized: 1921
Territory: Plainfield and territory included between Elizabeth, Bound Brook, Metuchen, and Watchung, N. J.
Place of Meeting: Elizabeth Carteret Hotel, Elizabeth, and Plainfield Masonic Temple, Plainfield
Local Organization: Plainfield Engineers Club, Singer Engineering Society
Number of Members: 183

Executive Committee

W. B. Updegraff, *Chairman*
R. S. Brescka, *Vice-Chairman*
G. E. Leavitt, Jr., *Secretary*
H. I. Lewis, *Treasurer*
J. P. Faber
D. V. Waters

PROVIDENCE

Organized: 1920
Territory: Radius of thirty miles from Providence, R. I.
Place of Meeting: Providence Engineering Society Building, 195 Angell St., Providence, R. I.
Local Organization: Providence Engineering Society
Number of Members: 163

Executive Committee

F. A. Chiffelle, *Chairman*
S. A. Vaule, *Vice-Chairman*
A. W. Calder, Jr., *Secretary-Treasurer*
F. S. Blackall, Jr.
Z. R. Bliss
A. C. Chick
E. W. Freeman
R. T. Ode
J. D. Robertson

RALEIGH

Organized: As a Branch, 1923; as a Section, 1927
Territory: Radius of sixty miles from Raleigh, N. C.
Place of Meeting: N. C. State College, Raleigh, N. C.
Local Organization: N. C. Engineering Council, Raleigh Engineers Club
Number of Members: 19

Executive Committee

R. M. Rothgeb, *Chairman*
R. S. Wilbur, *Vice-Chairman*
F. B. Turner, *Secretary-Treasurer*
E. G. Hoefer
R. Holt
C. E. Kerchner
H. H. Vance

ROCHESTER

Organized: 1919
Territory: Radius of thirty miles from Rochester, N. Y.
Place of Meeting: Rochester Engineering Society Rooms, Sagamore Hotel

Local Organization: Rochester Engineering Society, Sagamore Hotel
Luncheon Meeting every Tuesday at 12:15 P. M. at Sagamore Hotel
Number of Members: 100

Executive Committee

K. B. Castle, Jr., *Chairman*
Howard Harding, *Vice-Chairman*
J. G. McChesney, *Secretary-Treasurer*
W. T. Cowell
T. F. Hooker
M. D. Lee
W. D. Seeley

ROCK RIVER VALLEY

Organized: 1926
Territory: Radius of thirty miles from Rockford, Ill.
Local Organization: Rockford Engineering Society
Number of Members: 52

Executive Committee

H. Hall, *Chairman*
R. C. Glazebrook, *Vice-Chairman*
R. Hessellund, *Secretary-Treasurer*
L. Geddes
Herman Hugle
A. C. Mattison
W. R. Shedd

ST. JOSEPH VALLEY

Organized: 1929
Territory: Counties of La Porte, Starke, Pulaski, St. Joseph, Marshall, Fulton, Elkhart, and Kosciusko in Indiana, and Cass and Berrien Counties in Michigan
Place of Meeting: Morningside Hotel, South Bend, Ind.
Local Organization: St. Joseph Valley Engineers' Club
Number of Members: 26

Executive Committee

C. R. Adams, *Chairman*
C. C. Wilcox, *Vice-Chairman*
K. W. Knorr, *Secretary-Treasurer*

ST. LOUIS

Organized: 1909
Territory: Radius of thirty miles from St. Louis, Mo.
Place of Meeting: Place varies
Local Organization: Engineers' Club of St. Louis
Number of Members: 193

Executive Committee

G. L. Shanks, *Chairman*
P. H. Buxton, *Vice-Chairman*
E. H. Sager, *Secretary-Treasurer*
R. M. Boyles
David Larkin
A. J. Leussler

SAN FRANCISCO

Organized: 1910
Territory: All territory north of the northern boundaries of the counties of San Luis Obispo, Kern, and San Bernardino
Place of Meeting: Engineers' Club, 206 Sansome St.
Luncheon Meetings every Thursday at 12:00 noon at the Engineers' Club
Local Organization: San Francisco Engineers' Club
Number of Members: 332

Executive Committee

O. B. Lyman, *Chairman*
R. L. Grutzmacher, *Vice-Chairman*
K. B. Anderson, *Secretary-Treasurer*
C. V. Finch
F. E. Russell
G. L. Sullivan
F. W. Collins, *Ex-Officio*

SAVANNAH

Organized: 1923
Territory: Radius of 125 miles from Savannah in Georgia
Place of Meeting: Savannah Hotel
Local Organization: Engineers' Council of Savannah Chamber of Commerce
Number of Members: 17

Executive Committee

B. J. Sams, *Chairman*
L. C. Roesel, *Vice-Chairman*
T. R. Jones, *Secretary-Treasurer*
W. H. Artley
D. E. Kehoe
A. M. Ormond

SCHENECTADY

Organized: As a Branch, 1919; as a Section, 1927
Territory: Radius of thirty miles from Schenectady, N. Y.
Place of Meeting: Edison Club Hall
Number of Members: 153

Executive Committee

A. I. Lipetz, *Honorary-Chairman*
J. E. Anderson, *Chairman*
A. J. Larrecq, *Secretary*
J. K. Salisbury, *Treasurer*
B. O. Buckland
H. M. Otto
E. E. Parker
E. L. Robinson

SOUTH TEXAS

Organized: 1919
Territory: South Texas and the northern part of the State not included in the North Texas Section territory
Place of Meeting: Electric Bldg., Houston, Tex.
Number of Members: 120

Executive Committee

W. B. Preston, *Chairman*
B. E. Short, *Vice-Chairman*
J. J. King, *Secretary-Treasurer*
W. T. Alliger
D. D. Alton
F. G. D. Muller
J. H. Pound
F. D. Rahm
J. M. Robertson
W. W. Scott
W. B. Tuttle
R. M. Wingren

SUSQUEHANNA

Organized: 1927
Territory: Counties of Cumberland, Dauphine, Lebanon, Adams, York, and Lancaster
Place of Meeting: Engineering Society of York
Local Organization: Engineering Society of York and Engineers' Society of Pennsylvania, Harrisburg, Pa.
Number of Members: 75

Executive Committee

Alfred Jones, *Chairman*
C. G. A. Schmidt, Jr., *Vice-Chairman*
H. B. Martin, *Secretary*
E. D. Clark
A. Bowman Snavely
O. G. Wheat

SYRACUSE

Organized: 1920
Territory: Radius of thirty miles from Syracuse, N. Y.
Place of Meeting: Ball Room of the Onondaga Hotel
Local Organization: The Technology Club of Syracuse
Number of Members: 76

Executive Committee

E. W. Zimmerman, *Chairman*
M. B. Moyer, *Vice-Chairman*
D. V. Shetland, *Secretary-Treasurer*
D. W. Diefendorf
W. O. Hildreth
R. C. Paul
M. F. Williams

TOLEDO

Organized: 1920
Territory: Radius of thirty miles from Toledo, Ohio
Place of Meeting: University Club, Toledo, Ohio
Local Organization: Affiliated Technical Societies of Toledo
Number of Members: 50

Executive Committee

J. R. Emery, *Chairman*
E. L. McBee, *Vice-Chairman*
C. W. Kirsch, *Secretary-Treasurer*
H. W. Carter
Edward Farmer
H. O. Hem
H. H. Kerr
C. R. Pomeroy
E. W. Weaver

TRI-CITIES

Organized: 1920
Territory: Radius of thirty miles from Moline, Ill.
Place of Meeting: Rock Island, Ill., Moline, Ill., and Davenport, Iowa
Luncheon Meeting every Wednesday, Davenport Hotel, 12:00 Noon
Number of Members: 68

Executive Committee

R. M. Barnes, *Chairman*
J. H. Ploehn, *Vice-Chairman*
C. A. Carlson, *Secretary-Treasurer*
E. G. Erickson
J. M. Hartman
W. P. Hunt

UTAH

Organized: 1923
Territory: State of Utah
Place of Meeting: University Club, Salt Lake City
Local Organization: Utah Society of Engineers
Number of Members: 33

Executive Committee

J. Billeter, *Chairman*
J. D. Roberts, *Vice-Chairman*
W. D. Turpin, *Secretary-Treasurer*
W. J. Cope
E. W. Pace
N. L. Stewart

UTICA

Organized: 1920
Territory: Radius of thirty miles from Utica, N. Y.
Local Organization: Mohawk Valley Technical Club
Number of Members: 13

Executive Committee

E. G. Munson, *Chairman*
Rex Witherbee, *Secretary-Treasurer*
W. J. Clement

VIRGINIA

Organized: 1919
Territory: State of Virginia
Place of Meeting: Richmond, Norfolk, Charlottesville, Roanoke, University, Petersburg
Local Organization: Central Virginia Engineers Club
Number of Members: 122

Executive Committee

E. B. Norris, *Chairman*
A. F. Keane, *Vice-Chairman*
J. B. Jones, *Secretary*
N. W. Conner, *Treasurer*
C. H. Harris
J. B. Jones
E. F. Kroner
E. W. Miller
F. T. Morse
J. B. Woodward, Jr.

WASHINGTON, D. C.

Organized: 1919
Territory: District of Columbia
Place of Meeting: Auditorium, Potomac Electric Power Co., 10th & E Sts., Washington, D. C.
Number of Members: 189

Executive Committee

M. X. Wilberding, *Chairman*
J. Fulton Fox, *Vice-Chairman*
W. B. Ensinger, *Secretary-Treasurer*
J. G. Adair
Andrew T. Dupont
H. G. Thielscher
M. E. Weschler

WATERBURY

Organized: 1917, as a Branch of Connecticut Section; reorganized as a Section, 1923
Territory: Litchfield County and a portion of New Haven County
Place of Meeting: Elton Hotel
Number of Members: 81

Executive Committee

A. L. Davis, *Chairman*
L. G. Bean, *Vice-Chairman*
C. W. Rush, *Secretary-Treasurer*
M. J. Dempsey
R. L. Palatine
R. C. Perry

WESTERN MASSACHUSETTS

Organized: 1922
Territory: Includes counties of Berkshire, Franklin, Hampden, and Hampshire
Place of Meeting: Highland Hotel, Springfield, Mass.
Local Organization: Engineering Society of Western Massachusetts
Number of Members: 84

Executive Committee

C. E. Maynard, *Chairman*
D. W. Williamson, *Vice-Chairman*
L. G. Carlton, *Secretary-Treasurer*
Lester Campbell
J. C. Robinson
R. L. Bosworth, *Ex-Officio*

WESTERN WASHINGTON

Organized: 1919
Territory: State of Washington west of the Columbia River with the exception of the territory included in the thirty-mile radius of Portland, Ore.
Place of Meeting: Engineers' Club, Arctic Bldg., Seattle, Wash.
Local Organization: Seattle Engineers' Club
Luncheon Meetings daily at noon at Engineers' Club, Seattle, Wash.
Number of Members: 91

Executive Committee

R. L. Dyer, *Chairman*
E. I. Flateboe, *Vice-Chairman*
R. E. Walter, *Secretary-Treasurer*
D. F. Bartholet
Barton Cruikshank
Wm. R. Gibson
H. E. Peters
E. O. Eastwood, *Ex-Officio*

WEST VIRGINIA

Organized: 1925
Territory: State of West Virginia, South of Parallel 39
Place of Meeting: Charleston, W. Va.
Number of Members: 64

Executive Committee

E. L. Hudson, *Chairman*
J. F. Malloy, *Secretary-Treasurer*
H. B. Hickman, *Assistant Secretary*
E. R. Habicht
L. D. Hayes
J. H. Jaecker
O. C. Lange
R. E. Walker

WORCESTER

Organized: 1915
Territory: Radius of thirty miles from Worcester, Mass.
Place of Meeting: Sanford Riley Hall, Worcester Poly. Inst.
Local Organization: Worcester Engineering Society
Number of Members: 139

Executive Committee

R. Erickson, *Chairman*
C. P. Howard, *Vice-Chairman*
W. S. Snow, *Secretary-Treasurer*
D. G. Downing
R. F. Gow
S. N. McCaslin
O. Muller
F. W. Roys
E. R. Spaulding

YOUNGSTOWN

Organized: 1928
Territory: Counties of Trumbull, Mahoning, and Columbiana in Ohio, and Mercer and Lawrence in Pennsylvania
Place of Meeting: Central Y.M.C.A., Youngstown, Ohio
Number of Members: 52

Executive Committee

Erling Oyen, *Chairman*
G. Warren, *Vice-Chairman*
C. W. Foard, *Secretary-Treasurer*
F. Bowers
E. Davenport
L. A. Klein
A. G. McHugh
H. W. Smith
J. L. Wick

Special Research Committees

(Personnel of Standing Committees, p. RI-2)

LUBRICATION

Appointed October, 1915, to investigate the fundamental problems of lubrication, to formulate results of investigations previously made, and to keep in touch with contemporary research in this field

(Reorganized May, 1936)

G. B. Karelitz, *Chairman*
S. J. Needs, *Secretary*
A. L. Beall
Oscar Bridgeman
W. E. Campbell
Hans Dahlstrand
H. A. Everett
A. E. Flowers
R. C. Geniesse
Raymond Haskell
M. D. Hersey
L. P. Michael
G. L. Neely
B. L. Newkirk
A. E. Norton
J. F. Pelley
E. Wooler

FLUID METERS

Appointed 1916 to develop the theory of fluid meters of all kinds and to report on the best methods for their installation and use

(Reorganized July, 1926)

R. J. S. Pigott, *Chairman*
J. R. Carlton, *Secretary*
H. S. Bean
S. R. Beitler
R. K. Blanchard
W. W. Frymoyer
Louis Gess
T. H. Kerr
W. S. Pardoe
E. S. Smith, Jr.
R. E. Sprenkle
E. C. M. Stahl
T. R. Weymouth
M. J. Zucrow

THERMAL PROPERTIES OF STEAM

Appointed in December, 1921, to direct research on the thermal properties of water-vapor and steam from 0 C to the upper limits of temperature and pressure

(Reorganized April, 1929)

G. L. Bourne, *Chairman*
W. L. Abbott, *Vice-Chairman*
H. N. Davis
H. C. Dickinson
Alex Dow
A. M. Greene, Jr.
R. C. H. Heck
D. S. Jacobus
J. H. Keenan
F. G. Keyes
L. S. Marks
G. A. Orrok
R. J. S. Pigott
H. V. Rasmussen
E. L. Robinson

STRENGTH OF GEAR TEETH

Appointed in December, 1921. Is investigating factors affecting the strength and life of gear teeth

R. E. Flanders, *Chairman*
C. H. Logue, *Secretary*
C. G. Barth
Earle Buckingham
A. M. Greene, Jr.
C. W. Ham
F. E. McMullen
E. W. Miller
Ernest Wildhaber

CUTTING OF METALS

Appointed in September, 1923. Is studying the problems of metal cutting, including tool materials, tool design, lubrication, cooling, and speeds and feeds

Coleman Sellers, 3d, *Chairman*
L. N. Gulick, *Secretary*
L. P. Alford
O. W. Boston
R. C. Deale
A. L. DeLeeuw
Malcolm F. Judkins

MECHANICAL SPRINGS

Appointed May, 1924, to determine the status of the mechanical-spring art, to promote and conduct necessary and adequate research, and to develop the art to the point of standardization

J. R. Townsend, *Chairman*
C. T. Edgerton, *Secretary*
C. E. Barba
W. G. Brombacher
R. W. Cook
W. T. Donkin
Rupen Eksergian
G. E. Hansen
Benjamin Liebovitz
David Lofts
(R. D. Brizzolara, *Alternate*)
A. N. Lukens
D. J. McAdam, Jr.
R. E. Peterson
J. B. Reynolds
J. W. Rockefeller, Jr.
B. W. St. Clair
M. F. Sayre
Keith Williams
J. Kaye Wood
F. P. Zimmerli
O. B. Zimmerman

ELEVATOR SAFETIES

Appointed June, 1924, as a subcommittee of the Sectional Committee on Safety Code for Elevators, to study the function and operation of elevator safeties and buffers and their associated mechanisms and to develop methods of test for the approval of elevator safety devices

D. J. Purinton, *Chairman*
O. P. Cummings, *Vice-Chairman*
J. A. Dickinson, *Secretary*
Bassett Jones
D. L. Lindquist
M. G. Lloyd
J. J. Matson
M. B. McLauthlin
W. S. Paine

EFFECT OF TEMPERATURE ON THE PROPERTIES OF METALS

Appointed December, 1924, as a joint research committee of the A.S.T.M. and the A.S.M.E. to encourage the investigation and accumulation of data on the properties of metals used in the mechanic arts at extremely high and low temperatures

(Total personnel, 75)

H. J. French, *Chairman*
N. L. Mochel, *Secretary*
R. H. Aborn
A. D. Bailey
F. E. Bash
R. A. Bull
E. S. Dixon
F. B. Foley
H. W. Gillett
H. J. Kerr
H. W. Maack
C. E. MacQuigg
D. J. McAdam, Jr.
P. E. McKinney
E. L. Robinson
A. E. White

BOILER FEEDWATER STUDIES

Appointed March, 1925, as a Joint Research Committee of the American Boiler Manufacturers Association, American Railway Engineering Association, American Water Works Association, Edison Electric Institute, the American Society for Testing Materials, and the A.S.M.E., to study methods of analysis and treatment of boiler feedwater for stationary and railroad practice

Executive Committee (Total personnel 42)

C. H. Fellows, *Chairman*
R. C. Bardwell, *Vice-Chairman*
J. B. Romer, *Secretary*
Edward Bartow
† A. G. Christie
R. E. Coughlin
B. J. Cross
Max Hecht
† C. F. Hirshfeld
W. F. Keenan, Jr.
F. N. Speller
M. F. Stack
E. H. Tenney
C. P. Van Gundy
† A. E. White
Abel Wolman

CONDENSER TUBES

Appointed May, 1925, to investigate and report on the causes of failure of tubes used in steam condensers and similar heat interchange apparatus

A. E. White, *Chairman*
Bert Houghton, *Vice-Chairman*
P. A. Bancel
D. K. Crampton
H. M. Cushing
R. E. Dillon
O. B. J. Fraser
J. R. Freeman, Jr.
V. M. Frost
C. F. Harwood
C. F. Hirshfeld
G. C. Holder
H. W. Leitch
E. F. Miller
W. B. Price
M. F. Stack
H. A. Staples
W. R. Webster
Director, Bureau of Engineering, U. S. Navy Department

† Official A.S.M.E. representatives serving on this committee.

BOILER FURNACE REFRACTORIES

Appointed June, 1925, to determine the principal factors governing the failure of refractories in various types of installations, to subject these factors to detailed experimental analysis, to undertake the formulation of suitability tests and, if necessary, to attempt to develop a suitable refractory to meet the needs of severe service

W. A. Carter, *Chairman*
S. H. Barnum
G. A. Bole
M. C. Booze
W. H. Fulweiler
C. B. Grady
R. A. Heindl
C. F. Hirshfeld
O. P. Hood
R. K. Hursh
N. E. Lewis
J. S. McDowell
(F. A. Harvey, *Alternate*)
S. J. McDowell
Percy Nicholas
S. M. Phelps
E. B. Powell
R. A. Sherman
R. B. Sosman
L. J. Trostel
G. B. Wilkes

WORM GEARS

Appointed May, 1927, to investigate certain problems in connection with the action of worm gear drives and to recommend improvements in their design, manufacture, and use

Earle Buckingham, *Chairman*
G. H. Acker
L. R. Buckendale
W. H. Himes
D. L. Lindquist
A. A. Ross
B. F. Waterman
Representative of Bureau of Engineering, U. S. Navy Department

VELOCITY MEASUREMENT OF FLUID FLOW

Appointed October, 1927, to sponsor the development of an absolute method for determining the velocity of the flow of fluids by means of the location of nodal points in wave systems

W. F. Durand, *Chairman*
T. R. Weymouth

MEASURES OF MANAGEMENT

Appointed March, 1928, to attempt the reconciliation of certain economic laws affecting production, to develop formulas for management, and to collect and report information on management research

W. E. Freeland, *Chairman*
F. E. Raymond, *Secretary*
J. H. Barber
T. H. Brown
R. C. Davis
G. E. Hagemann

ABSORPTION OF RADIANT HEAT IN BOILER FURNACES

Appointed April, 1928, to make a study of the absorption of radiant heat in boiler furnaces with the purpose of developing recommendations on improved furnace design

W. J. Wohlenberg, *Chairman*
E. G. Bailey
R. M. Gates
C. W. Gordon
E. L. Lindseth
G. A. Orrok
R. J. S. Pigott
John Van Brunt

HEAVY DUTY ANTI-FRICTION BEARINGS

Appointed March, 1929, to investigate the possibilities and limitations of anti-friction bearings when applied to roll necks of rolling mills

W. Trinks, *Chairman*
J. H. Hitchcock, *Secretary*
H. E. Brunner
W. R. Clark
H. H. Talbot
S. M. Weckstein
H. A. Winne

REMOVAL OF ASH AS MOLTEN SLAG FROM POWDERED-COAL FURNACES

Appointed March, 1929, to investigate the adding of fluxes as a means of increasing the fluidity of slag in boiler furnaces and thus permit its removal at operating furnace temperatures

K. M. Irwin, *Chairman*
Andrew Carnegie
T. G. Coghlan
H. M. Cushing
C. F. Hirshfeld
Percy Nicholls
E. B. Powell
P. B. Rice

STRENGTH OF VESSELS UNDER EXTERNAL PRESSURE

Appointed June, 1929, to develop reliable design data on the strength of cylindrical and spherical surfaces under external pressure, particularly with reference to jacketed vessels

W. D. Halsey, *Chairman*
Thomas Griswold, Jr.
F. V. Hartman
M. B. Higgins
T. McL. Jasper
A. W. Limont, Jr.
Carl Rigdon
H. E. Saunders
E. E. Shanor
J. H. Taylor
(F. S. G. Williams, *Alternate*)
D. B. Wesstrom
D. F. Windenburg

AUTOMATIC OIL PIPE LINE PUMPING STATIONS

Authorized March, 1930, to develop methods of automatic control for oil pipe line pumping stations

W. G. Heltzel, *Chairman*
J. N. Hunter, *Vice-Chairman*
T. D. Williamson, *Secretary*
W. S. Baugh
W. C. Dreyer
W. H. Elliot
J. B. Ford
L. T. Gibbs
F. A. Graham
C. F. Guinn
A. N. Horne
J. K. McGoldrick
J. M. McGregor
J. B. McMahon
R. L. Middleton
O. L. Olsen
William Parkerson
W. R. Reed
F. A. Stivers
W. H. Stueve
Fred Thilenius
J. B. Thomas
F. E. Warterfield
Oscar Wolf

WIRE ROPE

Approved by Council January, 1931, to investigate existing rope so that it may be better understood and more effectively used

W. H. Fulweiler, *Chairman*
H. LeR. Brink
D. L. Lindquist
G. W. Martin
C. A. McCune
A. H. McDougall
B. V. E. Nordberg, Jr.
W. S. Paine
W. J. Ryan
George Simpson
L. E. Young

PRIME MOVERS FOR ROTARY DRILLING OF OIL WELLS

Approved by Council January, 1931, to investigate existing types of prime movers used for rotary drilling of oil wells as to their relative efficiencies, costs of operation, and general satisfaction

D. L. Trax, *Chairman*
Raymond Carr
W. H. Carson
R. R. Hawkins
H. W. Manley

CRITICAL PRESSURE STEAM BOILERS

Appointed June, 1931, to study the characteristics of high-pressure forced-circulation steam-generating units

A. A. Potter, *Chairman*
W. H. Armacost
A. D. Bailey
E. G. Bailey
A. G. Christie
F. S. Clark
C. H. Fellows
H. J. Kerr
M. W. Link
G. A. Orrok
H. L. Solberg
P. W. Thompson

SAMPLING PULVERIZED FUEL IN A MOVING GAS STREAM

Appointed November, 1932, to investigate the present methods of sampling pulverized fuel and to evolve a generally satisfactory method that may be adopted as a standard

K. M. Irwin, *Chairman*
F. M. Gibson, *Secretary*
John Blizard
Ollison Craig
M. D. Engle
C. S. Gladden
A. E. Grunert
R. M. Hardgrove
J. C. Hardigg
H. J. Klotz
Henry Kreisinger
J. W. MacKenzie
W. S. Morrison
G. B. Randall
R. C. Roe
E. H. Tenney

COTTON SEED PROCESSING

Appointed December, 1932, to study the mechanical problems involved in storing, conditioning, and cooking cotton seed meats

W. R. Woolrich, *Chairman*
Homer Barnes
E. L. Carpenter
C. E. Garner
B. J. Sams
R. B. Taylor

A.S.M.E. Representatives on Other Research Committees

See also A.S.M.E. Representatives on Other Activities, page RI-29

CORROSION COMMITTEE

American Society of Refrigerating Engineers
(To be appointed)

FATIGUE PHENOMENA OF METALS

American Society for Testing Materials
W. R. Webster

HEAT-TREATMENT OF ROCK DRILL STEELS

Advisory Board of the Bureau of Standards and Bureau of Mines
(To be appointed)

HIGHWAY RESEARCH

Advisory Board of National Research Council
J. G. Bergquist

NATIONAL COMMITTEE ON WOOD UTILIZATION

Department of Commerce, National Bureau of Standards
A. E. Hall

NON-FERROUS METALS AND ALLOYS

Advisory Committee to the National Bureau of Standards
C. H. Bierbaum

PROPERTIES OF REFRACTORY MATERIALS

Advisory Committee to the National Bureau of Standards
E. B. Powell

WATER FOR INDUSTRIAL USES

American Society for Testing Materials
G. D. Bearce

Standardization Technical Committees

(*Personnel of Standing Committee, p.* RI-2)

STANDARDIZATION AND UNIFICATION OF SCREW THREADS (B-1)

* *Joint sponsorship with the Society of Automotive Engineers. Sectional Committee originally organized in June, 1921. Reorganized in February, 1929*

A.S.M.E. Members (Total personnel, 41)

† R. E. Flanders, *Chairman*
Earle Buckingham, *Secretary*
E. J. Bryant
G. S. Case
T. G. Crawford
C. G. Holmberg
† A. M. Houser
H. C. E. Meyer
† P. V. Miller
R. H. Perry
O. B. Zimmerman

Subcommittee Chairmen

No. 1 on Scope, Arrangement and Editing of American National Standard, R. E. Flanders
No. 2 on Terminology and Thread Specifications, Except Gages, C. W. Bettcher
No. 3 on Special Threads and Twelve Pitch Series, Except Gages.
No. 4 on Acme and Other Similar Threads, Except Gages, E. Buckingham
No. 5 on Screw Thread Gages and Inspection, G. S. Case
No. 7 on Wood Screws, A. Boor

PIPE THREADS (B-2)

* *Joint sponsorship with the American Gas Association. Sectional Committee reorganized May, 1927*

A.S.M.E. Members (Total personnel, 48)

A. S. Miller, *Chairman*
A. F. Breitenstein
E. J. Bryant
E. S. Cornell, Jr.
J. J. Crotty
A. P. Denton
J. J. Harman
† A. M. Houser
F. B. Howell
A. H. Jarecki
J. O. Johnson
W. R. Kremer
P. V. Miller
F. H. Morehead
W. C. Morris
S. F. Newman
E. S. Sanderson
L. N. Shannon
W. D. Sizer
J. H. Williams

Subcommittee Chairmen

No. 1 on Editing and Gaging, A. M. Houser
No. 2 on Taper Pipe Threads, S. B. Terry
No. 3 on Straight Pipe Threads, A. S. Miller
No. 4 on Plumbers' Threads, A. F. Breitenstein
No. 5 on Screw Threads for Rigid Steel Conduit, James Barton
No. 6 on Special Threads for Thin Tubes, C. C. Winter

BALL AND ROLLER BEARINGS (B-3)

* *Joint sponsorship with the Society of Automotive Engineers. Sectional Committee organized December, 1920*

A.S.M.E. Members (Total personnel, 19)

† W. P. Kennedy, *Vice-Chairman*
† G. R. Bott
L. A. Cummings
F. G. Hughes
† G. E. Hulse
L. F. Nenninger
† A. E. Norton
Ernest Wooler

Subcommittee Chairman

Annular Ball Bearing, G. R. Bott

ALLOWANCES AND TOLERANCES FOR CYLINDRICAL PARTS AND LIMIT GAGES (B-4)

* *Sole sponsorship. Sectional Committee originally organized in June, 1920. Reorganized in September, 1930*

A.S.M.E. Members (Total personnel, 49)

F. E. Banfield, Jr.
(E. E. Blake, *Alternate*)
F. S. Blackall, Jr.
E. J. Bryant
† Earle Buckingham
† F. H. Colvin
R. E. W. Harrison
F. O. Hoagland
N. E. Jacobi
William Jetter
H. C. E. Meyer
P. V. Miller
W. C. Mueller
† E. C. Peck
W. C. Schoenfeldt
C. C. Stevens
O. B. Zimmerman

Subcommittee Chairman

No. 1 on Tolerance Systems, R. E. W. Harrison

* *Note:* All of the Standards Committees for which the Society is Sponsor or Joint Sponsor are organized under the procedure of the American Standards Association.

† Official A.S.M.E. representatives serving on this committee.

SMALL TOOLS AND MACHINE TOOL ELEMENTS (B-5)

* *Joint sponsorship with the National Machine Tool Builders Association and the Society of Automotive Engineers. Sectional Committee organized September, 1922*

A.S.M.E. Members (Total personnel, 26)

C. W. Spicer, *Chairman*
F. O. Hoagland, *Vice-Chairman*
J. B. Armitage
F. S. Blackall, Jr.
O. W. Boston
E. J. Bryant
Earle Buckingham
† F. H. Colvin
S. A. Einstein
† H. E. Harris
John Haydock
J. E. Lovely
† Simon MacKay
† W. C. Mueller
† E. R. Norris
Erik Oberg

Technical Committee No. 1 on T-Slots

A.S.M.E. Members (Total personnel, 11)

Erik Oberg, *Chairman*
J. B. Armitage
E. P. Burrell
† Harry Cadwallader, Jr.
Herman Casler
S. A. Einstein
R. T. Hazelton
† F. O. Hoagland
† E. R. Norris

Technical Committee No. 2 on Tool Posts and Shanks

A.S.M.E. Members (Total personnel, 9)

O. W. Boston, *Chairman*
F. S. Blackall, Jr.
† Granger Davenport
M. E. Lange

Technical Committee No. 3 on Machine Tapers

A.S.M.E. Members (Total personnel, 21)

F. S. Blackall, Jr., *Chairman*
J. B. Armitage
† E. J. Bryant
† Earle Buckingham
F. H. Colvin
J. B. Dillard
B. P. Graves
H. E. Harris
† F. O. Hoagland
J. H. Horigan
A. H. Lyon
L. F. Nenninger
E. J. Prindle
C. W. Spicer

SUBGROUP CHAIRMEN

Taper Series, F. S. Walters
Steep Taper Series, W. A. Timm
Dimensions, Tolerances and Gages, A. H. Lyon

Technical Committee No. 4 on Spindle Noses and Collets for Machine Tools

A.S.M.E. Members (Total personnel, 26)

J. E. Lovely, *Chairman*
L. F. Nenninger, *Secretary*
J. B. Armitage
B. P. Graves
F. O. Hoagland
A. M. Johnson
M. E. Lange
A. H. Lyon
J. H. Mansfield
H. W. Ruppel
L. D. Spence

SUBGROUP CHAIRMEN

No. 1 on Milling Machines, Small and Medium, J. B. Armitage
No. 2 on Large Milling Machines, A. H. Lyon
No. 3 on Grinding Machine Spindles, H. J. Griffing
No. 4 on Cutting Off Machines, W. H. Welch
No. 5 on Drilling Machines and Horizontal Boring Machines, W. A. Timm
No. 6 on Turning Machines, Including Automatic Screw Machines, Lathes, Automatic Lathes, Turret Lathes, and Automatic Chucking Machines, J. E. Lovely
No. 7 on Cutting and Hobbing Machines, A. L. Stewart
No. 8 on Correlation of Counter Proposals for Spindle Noses, J. E. Lovely

Technical Committee No. 5 on Milling Cutters

A.S.M.E. Members (Total personnel, 21)

J. B. Armitage
† A. N. Goddard
J. H. Horigan
G. L. Markland, Jr.
E. K. Morgan
† Erik Oberg
C. J. Oxford
E. D. Vancil

SUBGROUP CHAIRMEN

No. 1 on Profile Cutters, E. C. Vancil
No. 2 on Keyways, J. B. Armitage
No. 3 on Nomenclature, A. C. Danekind
No. 4 on Limits, J. H. Horigan
No. 5 on Formed Cutters, H. C. Hungerford
No. 6 on Hobs
No. 7 on Inserted Tooth Cutters, J. B. Armitage

Technical Committee No. 6 on Designations and Working Ranges of Machine Tools

A.S.M.E. Members (Total personnel, 19)

John Haydock, *Chairman*
Earle Buckingham
T. H. Doan, Jr.
B. P. Graves
J. J. McBride
E. R. Smith

Technical Committee No. 7 on Twist Drill Sizes

A.S.M.E. Members (Total personnel, 7)

W. C. Mueller, *Chairman*
J. H. Horigan
C. W. Spicer

Technical Committee No. 8 on Jig Bushings

A.S.M.E. Members (Total personnel, 8)

C. R. Alden, *Secretary*
J. H. Horigan
W. C. Mueller
C. J. Oxford
H. E. Wells

SUBGROUP CHAIRMAN

Liner Outer Diameters and Tolerances, W. C. Mueller

Technical Committee No. 9 on Punch Press Tools

A.S.M.E. Members (Total personnel, 16)

D. H. Chason
N. W. Dorman
H. E. Harris
W. C. Mueller
H. E. Wells

Technical Committee No. 10 on Circular Forming Tools and Holders

A.S.M.E. Members (Total personnel, 9)

W. C. Mueller, *Chairman*
William Hartman
L. D. Spence
H. E. Wells

Technical Committee No. 11 on Chucks and Chuck Jaws

A.S.M.E. Member (Total personnel, 9)

J. E. Lovely, *Chairman*

SUBGROUP CHAIRMAN

No. 1 on Master Chuck Jaws, J. E. Lovely
No. 2 on Adapters for Air Cylinders, J. E. Lovely

Technical Committee No. 12 on Cut and Ground Thread Taps

A.S.M.E. Member (Total personnel, 7)

W. C. Mueller

Technical Committee No. 13 on Splines and Splined Shafts

A.S.M.E. Members (Total personnel, 15)

C. W. Spicer, *Chairman*
J. B. Armitage
W. F. Groene
R. E. W. Harrison
F. O. Hoagland
J. E. Lovely
B. F. Waterman

SUBGROUP CHAIRMEN

Machine Tool Splines, R. E. W. HARRISON
Automotive Splines, W. L. BARTH
Involute Splines, P. L. TENNEY

TECHNICAL COMMITTEE NO. 14 ON ELECTRIC WELDING DIES AND ELECTRODE HOLDERS

A.S.M.E. Members (Total personnel, 14)

R. B. LINCOLN
N. McD. LONEY

TECHNICAL COMMITTEE NO. 16 ON ROTATING TOOL SHANKS

A.S.M.E. Members (Total personnel, 20)

E. J. BRYANT, *Chairman*
J. H. HORIGAN, *Secretary*
J. B. DILLARD
E. W. HOWE
W. C. MUELLER
C. J. OXFORD
H. E. WELLS

TECHNICAL COMMITTEE NO. 17 ON NOMENCLATURE FOR SMALL TOOLS AND MACHINE TOOL ELEMENTS

A.S.M.E. Members (Total personnel, 15)

O. W. BOSTON, *Chairman*
F. S. BLACKALL, JR.
F. H. COLVIN
H. E. HARRIS
F. O. HOAGLAND

Ex-Officio Members

C. R. ALDEN
B. P. GRAVES
A. N. GODDARD
C. J. OXFORD
C. W. SPICER
H. E. WELLS

TECHNICAL COMMITTEE NO. 18 ON MULTIPLE SPINDLE DRILLING HEADS

A.S.M.E. Member (Total personnel, 9)

H. E. WELLS

TECHNICAL COMMITTEE NO. 19 ON SINGLE POINT CUTTING TOOLS

A.S.M.E. Members (Total personnel, 2)

F. H. COLVIN, *Chairman*
O. W. BOSTON, *Secretary*

TECHNICAL COMMITTEE NO. 20 ON REAMERS

(Committee being formed)

GEARS (B-6)

** Joint sponsorship with the American Gear Manufacturers Association.*
Sectional Committee organized June, 1921

A.S.M.E. Members (Total personnel, 32)

B. F. WATERMAN, *Chairman*
† EARLE BUCKINGHAM, *Vice-Chairman*
G. H. ACKER
L. H. FRY
C. B. HAMILTON, JR.
D. T. HAMILTON
† O. A. LEUTWILER
G. L. MARKLAND, JR.
H. E. VEHSLAGE

SUBCOMMITTEE CHAIRMEN

No. 1 on Program, B. F. WATERMAN
No. 2 on Editing Reports, B. F. WATERMAN
No. 3 on Nomenclature, D. T. HAMILTON
No. 4 on Tooth Form (Spur Gears), U. S. EBERHARDT
No. 5 on Helical Gears, W. P. SCHMITTER
No. 6 on Worm Gears, T. R. RIDEOUT
No. 7 on Bevel Gears, F. E. McMULLEN
No. 8 on Materials, C. B. HAMILTON, JR.
No. 9 on Inspection, J. P. BREUER
No. 10 on Horse Power Rating, E. BUCKINGHAM

PIPE FLANGES AND FITTINGS (B-16)

** Joint sponsorship with the Heating, Piping, and Air Conditioning Contractors National Association and the Manufacturers Standardization Society of the Valve and Fittings Industry. Sectional Committee organized October, 1921*

A.S.M.E. Members (Total personnel, 55)

† C. P. BLISS, *Chairman*
J. J. HARMAN, *Secretary*
† LESTER BENOIT
A. L. BROWN
W. R. CONARD
SABIN CROCKER
FERDINAND FINK
H. E. HALLER
J. S. HESS
FRANCIS HODGKINSON
† H. A. HOFFER
A. M. HOUSER
D. S. JACOBUS
L. H. JENKS
JOHN KNICKERBACKER
M. B. MACNEILLE
F. H. MOREHEAD
† E. L. MORELAND
† W. S. MORRISON
L. S. MORSE
A. L. PENNIMAN, JR.
WALTER SAMANS
† J. R. TANNER
J. H. TAYLOR
H. L. UNDERHILL
G. W. WATTS
J. H. WILLIAMS

SUBCOMMITTEE CHAIRMEN

No. 1 on Cast Iron Flanges and Flanged Fittings, A. M. HOUSER
No. 2 on Screwed Fittings, F. H. MOREHEAD
No. 3 on Steel Flanges and Flanged Fittings, C. P. BLISS
No. 4 on Materials and Stresses, A. M. HOUSER
No. 5 on Face to Face Dimensions of Ferrous Flanged Valves, J. R. TANNER
No. 6 on Malleable Iron or Steel Brass Seat Unions, C. P. BLISS
No. 7 on Rating of Pipe Fittings, H. C. HEATON
No. 8 on Marking of Pipe Fittings, W. S. MORRISON
No. 9 on Port Openings, W. W. HUBBARD

SHAFTING (B-17)

** Sole sponsorship. Organized October, 1918*

A.S.M.E. Members (Total personnel, 15)

† C. M. CHAPMAN, *Chairman*
† A. A. ADLER
E. E. GREVE
H. C. E. MEYER
L. C. MORROW
C. W. SPICER
† G. N. VAN DERHOEF
† L. W. WILLIAMS

SUBCOMMITTEE CHAIRMEN

No. 1 on Shafting Dimensions, L. W. WILLIAMS
No. 2 on Stock Key Sizes
No. 3 on Code for Design of Transmission Shafting
No. 4 on Taper Keys, J. E. BUSHNELL
No. 5 on Woodruff Keys, L. C. MORROW

BOLT, NUT AND RIVET PROPORTIONS (B-18)

** Joint sponsorship with the Society of Automotive Engineers. Sectional Committee organized March, 1922*

A.S.M.E. Members (Total personnel, 57)

† A. E. NORTON, *Chairman*
H. E. ALDRICH
F. C. BILLINGS
B. G. BRAINE
(D. L. BRAINE, *Alternate*)
ELLWOOD BURDSALL
G. S. CASE
T. G. CRAWFORD
H. P. FREAR
HERMAN KOESTER
S. F. NEWMAN
R. J. WHELAN
E. M. WHITING
V. R. WILLOUGHBY
(J. J. McBRIDE, *Alternate*)
O. B. ZIMMERMAN

SUBCOMMITTEE CHAIRMEN

No. 1 on Large and Small Rivets, E. L. COCHRANE
No. 2 on Wrench Head Bolts and Nuts, T. D. RUDDOCK
No. 3 on Slotted Head Proportions, E. W. REED
No. 4 on Track Bolts and Nuts, C. W. SQUIER
No. 5 on Round Unslotted Head Bolts (Carriage Bolts)
No. 6 on Plow Bolts, O. B. ZIMMERMAN
No. 7 on Body Dimensions and Materials
No. 8 on Nomenclature, G. S. CASE
No. 9 on Socket Head Cap and Set Screws, H. KOESTER

PLAIN AND LOCK WASHERS (B-27)

* *Joint sponsorship with the Society of Automotive Engineers. Sectional Committee organized August, 1925*

A.S.M.E. Members (Total personnel, 40)

Eugene Caldwell
T. G. Crawford
† B. S. Lewis
C. H. Loutrel
J. J. McBride
H. C. E. Meyer
E. H. Waring
E. M. Whiting
O. B. Zimmerman

Subcommittee Chairmen

No. 1 on Plain Washers
No. 2 on Lock Washers, C. H. Loutrel

TRANSMISSION CHAINS AND SPROCKETS (B-29)

* *Joint sponsorship with the Society of Automotive Engineers and the American Gear Manufacturers Association. Sectional Committee organized September, 1917. Reorganized December, 1926*

A.S.M.E. Members (Total personnel, 15)

† F. V. Hetzel, *Chairman*
W. J. Belcher
Joseph Joy
† L. V. Ludy
† E. B. Nichols
D. B. Perry
G. A. Young
O. B. Zimmerman

CODE FOR PRESSURE PIPING (B-31)

* *Sole sponsorship. Sectional Committee organized March, 1926*

A.S.M.E. Members (Total personnel, 89)

E. B. Ricketts, *Chairman*
R. E. Bryant
G. S. Coffin
H. C. Cooper
Sabin Crocker
(J. H. Walker, *Alternate*)
H. D. Edwards
C. A. Ellis
Charles Fitzgerald
W. M. Graff
O. S. Hagerman
H. E. Haller
J. J. Harman
J. S. Haug
(E. B. Severs, *Alternate*)
J. S. Hess
H. A. Hoffer
G. G. Hollins
† A. M. Houser
† Alfred Iddles
J. H. Lawrence
Edward Lenz
M. B. MacNeille
G. W. Martin
H. C. E. Meyer
J. W. Moore
F. H. Morehead
H. H. Morgan
W. S. Morrison
A. W. Moulder
E. W. Norris
G. A. Orrok
A. L. Penniman, Jr.
† C. S. Robinson
G. W. Saathoff
G. K. Saurwein
H. S. Smith
(H. H. Moss, *Alternate*)
F. N. Speller
C. G. Spencer
J. R. Tanner
J. H. Vance
H. L. Whittemore
J. H. Williams
T. F. Wolfe
G. H. Woodroffe

Subcommittee Chairmen

No. 1 on Plan and Scope and Editing, Sabin Crocker
No. 2 on Power Piping, J. H. Lawrence
No. 3 on Hydraulic Piping
No. 4 on Gas and Air Piping, Alfred Iddles
No. 5 on Refrigerating Piping, A. H. Baer
No. 6 on Oil Piping
No. 7 on Piping Materials and Identification
No. 8 on Fabrication Details, C. G. Spencer
No. 9 on Code for District Heating Piping, D. S. Boyden

WIRE AND SHEET METAL GAGING SYSTEMS (B-32)

* *Joint sponsorship with the Society of Automotive Engineers. Sectional Committee organized November, 1927*

A.S.M.E. Members (Total personnel, 28)

† F. W. Holland
J. F. Howe

Subcommittee Chairmen

No. 1 on Flat Stocks
No. 2 on Wires and Rods, E. E. Rose
No. 3 on Tubing, Piping, Conduit and Casing, F. H. Nullmeyer

SCREW THREADS FOR HOSE COUPLINGS (B-33)

* *Sole sponsorship. Sectional Committee organized August, 1928*

A.S.M.E. Members (Total personnel, 28)

A. L. Brown, *Secretary*
† A. F. Breitenstein
W. L. Curtiss
† W. E. Dunham
J. J. Harman
(F. C. Ernst, *Alternate*)
A. M. Houser
H. C. E. Meyer
J. H. Williams

Subcommittee Chairmen

No. 1 to Draft Recommended Specifications, J. H. Howland
No. 2 on Basic Thread Dimensions, D. R. Miller

WROUGHT IRON AND WROUGHT STEEL PIPE AND TUBING (B-36)

* *Joint sponsorship with the American Society for Testing Materials. Sectional Committee organized April, 1928*

A.S.M.E. Members (Total personnel, 45)

H. H. Morgan, *Chairman*
Sabin Crocker, *Secretary*
H. E. Aldrich
J. B. Aston
L. D. Burritt
† A. M. Houser
† D. S. Jacobus
† (F. S. Clark, *Alternate*)
H. C. E. Meyer
F. H. Morehead
C. W. Mowry
† H. B. Oatley
A. L. Penniman, Jr.
(A. B. Morgan, *Alternate*)
F. N. Speller
J. R. Tanner
A. E. White
H. LeR. Whitney
G. H. Woodroffe

Subcommittee Chairmen

No. 1 on Plan, Scope and Editing, H. H. Morgan
No. 2 on Pipe and Tubing for Low Temperature Service, J. J. Shuman
No. 3 on Pipe and Tubing for High Temperature Service, J. R. Tanner
No. 4 on Materials, F. H. Morehead

PRESSURE AND VACUUM GAGES (B-40)

* *Sole sponsorship. Sectional Committee organized July, 1930*

A.S.M.E. Members (Total personnel 46)

M. D. Engle, *Chairman*
† A. W. Lenderoth, *Secretary*
E. J. Bryant
† J. P. Cavanaugh
Paul Diserens
W. F. Jones
R. J. Kehl
† J. C. McCune
A. H. Morgan
† S. A. Moss
H. B. Reynolds
C. Z. Rosencrans
W. C. Schoenfeldt

Subcommittee Chairmen

No. 1 on Plan and Scope, M. D. Engle
No. 2 on Definitions, C. F. Schwep
No. 3 on Gage Sizes and Mounting Dimensions, H. B. Reynolds
No. 4 on Accuracy and Test Methods, O. J. Hodge

STOCK SIZES, SHAPES AND LENGTHS FOR HOT AND COLD FINISHED IRON AND STEEL BARS (B-41)

* *Sole sponsorship. Sectional Committee organized April, 1929*

A.S.M.E. Members (Total personnel, 27)

J. B. Aston
F. H. Dechant
† L. W. Williams
G. H. Woodroffe
O. B. Zimmerman

Subcommittee Chairmen

No. 1 on Hot Rolled Steel, H. Wysor
No. 2 on Cold Finished Steels, L. E. Creighton
No. 3 on Hot Rolled Iron, G. H. Woodroffe

SPECIFICATIONS FOR LEATHER BELTING (B-42)

** Sole sponsorship. Sectional Committee organized February, 1931*

A.S.M.E. Members (Total personnel, 27)

H. T. Coates
†R. W. Drake
King Hathaway
G. A. Schieren
†C. O. Streeter
O. B. Zimmerman

Subcommittee Chairmen

No. 1 on Standard Specifications, R. C. Bowker
No. 2 on Recommendations for Selection, Care and Installation, G. A. Schieren

MACHINE PINS (B-43)

** Joint sponsorship with the Society of Automotive Engineers. Sectional Committee organized, March, 1926*

A.S.M.E. Members (Total personnel, 18)

†M. E. Steczynski, *Chairman*
†E. J. Bryant
J. J. McBride
H. C. E. Meyer
O. B. Zimmerman

Subcommittees

No. 1 on Straight, Taper and Dowel Pins
No. 2 on Split Pins

FOUNDRY EQUIPMENT AND SUPPLIES (B-45)

** Joint sponsorship with the American Foundrymen's Association. Sectional Committee organized February, 1931*

A.S.M.E. Members (Total personnel, 25)

E. S. Carman, *Chairman*
E. W. Ely
†F. W. Herendeen
(F. B. Howell, *Alternate*)
G. F. Jenks
A. S. Phelps
†H. P. Van Cleve
O. B. Zimmerman

Subcommittee Chairmen

No. 1, L. M. Sherwin
No. 2, E. S. Carman
No. 3, A. S. Phelps

CLASSIFICATION AND DESIGNATION OF SURFACE QUALITIES (B-46)

** Joint sponsorship with the Society of Automotive Engineers. Sectional Committee organized May, 1932*

A.S.M.E. Members (Total personnel, 62)

E. J. Bryant
John Cetrule
T. G. Crawford
†R. C. Deale
U. S. Eberhardt
S. A. Einstein
R. F. Gagg
J. J. Harman
†R. E. W. Harrison
F. V. Hartman
F. O. Hoagland
H. J. Holtzclaw
R. T. Kent
A. H. Lyon
M. J. Reed
F. C. Spencer
C. C. Stevens
J. S. Tawresey
J. R. Weaver
C. H. Whitaker
Ernest Wooler

Subcommittee Chairmen

No. 1 on Surfaces Produced by Tools and Abrasives, J. Cetrule
No. 2 on Surfaces Produced by Molds, Dies, Rolls or Any Other Means of Deforming Materials
No. 3 on Coated Surfaces, G. B. Hogaboom
No. 4 on Symbols for Indicating Surface Quality on Drawings, T. G. Crawford
No. 5 on Ways, Means and Apparatus for Measuring Quality of Surface, J. R. Weaver
No. 6 on Finance, R. E. W. Harrison

COMBUSTION SPACE FOR SOLID FUELS (B-50)

** Sole sponsorship. Sectional Committee organized June, 1933*

A.S.M.E. Members (Total personnel, 21)

C. E. Bronson, *Chairman*
W. G. Christy
John Hunter
A. J. Johnson
†V. G. Leach
T. A. Marsh
J. F. McIntire
R. H. Rowland
†John Van Brunt

Subcommittee Chairmen

No. 1 on Purpose and Scope, C. E. Bronson
No. 2 on Combustion and Design, T. A. Marsh
No. 3 on Warm Air Furnaces
No. 4 on Steel Heating Boilers, W. B. Russell
No. 5 on Cast Iron Boilers, J. F. McIntire

SCHEME FOR IDENTIFICATION OF PIPING SYSTEMS (A-13)

** Joint sponsorship with the National Safety Council. Sectional Committee organized June, 1922*

A.S.M.E. Members (Total personnel, 37)

W. L. Bunker
Crosby Field
Willis Lawrence
†W. S. Morrison
A. K. Ohmes
A. L. Penniman, Jr.
H. S. Smith
F. N. Speller

Subcommittee Chairmen

Identification by Colors, F. P. Ingalls
Classification, C. Field
Identification Markings Other Than Color, W. S. Morrison

MINIMUM REQUIREMENTS FOR PLUMBING AND STANDARDIZATION OF PLUMBING EQUIPMENT (A-40)

** Joint sponsorship with the American Society of Sanitary Engineering. Sectional Committee organized August, 1928*

A.S.M.E. Members (Total personnel, 47)

J. J. Crotty
J. F. Carney
O. E. Goldschmidt
A. M. Houser
G. W. Martin
(A. H. Morgan, *Alternate*)
†W. R. Webster

Subcommittee Chairmen

No. 1 on Minimum Requirements for Plumbing, W. C. Groeniger
No. 2 on Staple Vitreous China Plumbing Fixtures, E. S. Aitkin
No. 3 on Staple Porcelain (All Clay) Plumbing Equipment, E. S.
No. 4 on Enameled Sanitary Ware, A. H. Cline, Jr.
No. 5 on Traps, A. R. McGonegal
No. 6 on Brass Plumbing Products, J. L. Murphy
No. 7 on Brass Fittings for Flared Copper Tubes, F. L. Riggin
No. 8 on Cast Iron Soil Pipe and Fittings, J. J. Crotty
No. 9 on Gasoline, Oil and Grease Separators, J. J. Crotty
No. 10 on Threaded Cast Iron Pipe and Fittings for Drainage and Pressure Purposes
No. 11 on Soldered Fittings for Tubing, A. M. Houser

ELECTRIC MOTOR FRAME DIMENSIONS (C-28)

* *Joint sponsorship with the National Electrical Manufacturers Association. Sectional Committee organized November, 1927*

A.S.M.E. Members (Total personnel, 32)

C. A. Adams
S. A. Einstein
E. W. Ely
F. S. English
W. F. Jones
A. L. McHugh
P. G. Rhoads
† A. G. Trumbull
† E. H. Waring

ROLLED THREADS FOR SCREW SHELLS OF ELECTRIC SOCKETS AND LAMP BASES (C-44)

* *Joint sponsorship with the National Electrical Manufacturers Association. Sectional Committee organized March, 1929*

A.S.M.E. Members (Total personnel, 18)

† E. J. Bryant
† Earle Buckingham
A. B. Morgan
† E. S. Sanderson

LETTER SYMBOLS AND ABBREVIATIONS FOR SCIENCE AND ENGINEERING (Z-10)

* *Joint sponsorship with the A.A.A.S., A.I.E.E., A.S.C.E., S.P.E.E. Sectional Committee organized January, 1926. Reorganized October, 1935*

A.S.M.E. Members (Total personnel, 36)

S. A. Moss, *Vice-Chairman*
R. M. Anderson
E. P. Warner, *Alternate*
K. H. Condit
† R. J. S. Pigott
† S. R. Beitler, *Alternate*

Subcommittee Chairmen

No. 1 on Letter Symbols and Signs for Mathematics, A. A. Bennett
No. 2 on Symbols for Physics and Mechanics, R. E. Peterson
No. 3 on Symbols for Structural Analysis, Albert Haertlein
No. 4 on Symbols for Hydraulics, J. C. Stevens
No. 5 on Symbols for Heat and Thermodynamics, S. A. Moss
No. 6 on Symbols for Photometry and Illumination, E. C. Crittenden
No. 7 on Aeronautical Symbols
No. 8 on Symbols for Electric and Magnetic Quantities, J. F. Meyer
No. 9 on Symbols for Radio
No. 10 on Abbreviations for Engineering and Scientific Terms, G. A. Stetson

DRAWINGS AND DRAFTING ROOM PRACTICE (Z-14)

* *Joint sponsorship with the Society for the Promotion of Engineering Education, Sectional Committee organized July, 1926*

A.S.M.E. Members (Total personnel, 53)

F. DeR. Furman, *Chairman*
C. W. Keuffel, *Secretary*
C. E. Coolidge
T. G. Crawford
H. C. Fletcher
T. E. French
A. C. Harper
E. R. Hill
A. M. Houser
Alfred Iddles
† Samuel Ketchum
F. R. Laney
H. B. Langille
Rudolph Michel
F. W. Ming
E. B. Neil
J. W. Owens
F. C. Panuska
† E. S. Smith, Jr.

Subcommittee Chairmen

No. 1 on Specifications for Paper and Cloth, A. A. Coburn
No. 2 on Method of Indicating Dimensions
No. 3 on Lettering, T. G. Crawford
No. 4 on Layout, D. Baker
No. 5 on Line Work, S. Ketchum
No. 6 on Graphical Symbols on Drawings, T. E. French
Editing Committee, T. E. French

GRAPHIC PRESENTATION (Z-15)

* *Sole sponsorship. Sectional Committee organized November, 1926*

A.S.M.E. Members (Total personnel, 33)

† G. E. Hagemann, *Secretary*
C. M. Bigelow
Wallace Clark
H. G. Crockett
T. E. French
† D. B. Porter

Subcommittee Chairmen

No. 1 on Plan and Scope
No. 2 on Terminology
No. 3 on Preferred Practice in Graphic Presentation, A. H. Richardson
No. 4 on Engineering and Scientific Graphs, W. A. Shewhart

SPEEDS OF MACHINERY (Z-18)

* *Sole sponsorship. Sectional Committee organized May, 1928*

A.S.M.E. Members (Total personnel, 30)

† C. M. Bigelow
† R. C. Deale
Paul Diserens
F. S. English
D. C. Jackson
H. C. E. Meyer
John Reid
P. G. Rhoads
F. C. Spencer
O. B. Zimmerman

Subcommittee Chairmen

No. 1 on Plan and Scope, A. E. Hall
No. 2 on Questionnaire and Canvass to Industry, F. S. English
No. 3—Special Reviewing Committee

GRAPHICAL SYMBOLS AND ABBREVIATIONS FOR USE ON DRAWINGS (Z-32)

* *Joint sponsorship with American Institute of Electrical Engineers. Sectional Committee organized April, 1936*

A.S.M.E. Members (Total personnel 52)

E. E. Ashley
(John James, *Alternate*)
J. M. Barnes
† T. E. French
D. T. Hamilton
F. W. Holland
(J. J. Harman, *Alternate*)
A. M. Houser
I. J. Karassik
L. L. Munier
J. W. Owens
† F. C. Panuska
T. R. Thomas
T. P. Wright

Subcommittee Chairmen

No. 1 on Symbols for Use in Mechanical Engineering, T. E. French
No. 2 on Symbols for Use in Electrical Engineering, H. W. Samson

---

SHAFT COUPLINGS

Appointed in December, 1928

A.S.M.E. Members (Total personnel, 6)

D. J. McCormack, *Chairman*
R. A. McCarty
H. G. Reist
R. E. B. Sharp

DEVELOPMENT OF APPLICATIONS OF STATISTICS IN ENGINEERING AND MANUFACTURING

Joint sponsorship with the American Society for Testing Materials. Appointed in December, 1929

A.S.M.E. Members (Total personnel, 4)

W. H. Fulweiler
† L. K. Sillcox

STANDARD HEIGHT FOR LOADING PLATFORMS AT FREIGHT TERMINALS AND WAREHOUSES

Joint sponsorship with the Society of Terminal Engineers. Appointed in December, 1931

(Total personnel, 14)

† Official A.S.M.E. representative serving on this committee.

A. S. M. E. Representatives on Miscellaneous Standardization Committees

See also A.S.M.E. Representatives on Other Activities, page RI-29

ACOUSTICAL MEASUREMENTS AND TERMINOLOGY

** Sponsor body: Acoustical Society of America*

E. E. Free
(P. H. Bilhuber, *Alternate*)
R. V. Parsons
(J. S. Parkinson, *Alternate*)
W. B. White
(H. S. Read, *Alternate*)

AMERICAN MARINE STANDARDS COMMITTEE

Advisory Committee of Department of Commerce

J. W. Gray (H. W. Brown, *Alternate*)

BUILDING CODE COMMITTEE

Advisory Committee of Department of Commerce

Thornton Lewis

CLASSIFICATION OF COAL

** Sponsor body: American Society for Testing Materials*

F. R. Wadleigh

DRAINAGE OF COAL MINES

** Sponsor body: American Mining Congress*

M. J. Lide
O. M. Pruitt
W. M. White

ELECTRIC WELDING

** Sponsor bodies: American Institute of Electrical Engineers and the National Electrical Manufacturers Association*

N. McD. Loney

ELECTRICAL DEFINITIONS

** Sponsor body: American Institute of Electrical Engineers*

C. H. Berry
J. V. B. Duer

FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS

** Sponsor bodies: A.S.A. Fire Protection Group, National Bureau of Standards, and the American Society for Testing Materials*

E. C. Rack

FOREST FIRE PROTECTION

Committee of National Fire Protection Association

E. H. Davis

MANHOLE FRAMES AND COVERS

** Sponsor bodies: A.S.A. Telephone Group and American Society of Civil Engineers*

Anton Hansen
Homer Rupard

MARKING OF OBSTRUCTIONS TO AIR NAVIGATION

** Joint committee between aviation interests and combined utility interests*

J. E. Whitbeck (Jerome Lederer, *Alternate*)

METHODS OF RATING RIVERS

** Sponsor body: U. S. Geological Survey*

D. W. Mead

METHODS OF TESTING WOOD

** Sponsor bodies: U. S. Forest Service and the American Society for Testing Materials*

C. M. Bigelow

MISCELLANEOUS OUTSIDE COAL-HANDLING EQUIPMENT

** Sponsor body: American Mining Congress*

J. H. Stratton

PETROLEUM PRODUCTS AND LUBRICANTS

** Sponsor body: American Society for Testing Materials*

G. B. Karelitz
(H. J. Masson, *Alternate*)
W. F. Parish
(S. J. Needs, *Alternate*)

PETROLEUM SPECIFICATIONS

Advisory Board of U. S. Bureau of Mines

H. A. S. Howarth

PREFERRED NUMBERS

** Special Committee of A.S.A.*

K. H. Condit

ROTATING ELECTRICAL MACHINERY

** Sponsor bodies: American Institute of Electrical Engineers and National Electrical Manufacturers Association*

H. R. Sewell (C. A. Booth, *Alternate*)

SPECIFICATIONS FOR CAST IRON PIPE

** Sponsor bodies: American Gas Association, American Society for Testing Materials, American Water Works Association, National Electrical Manufacturers Association*

G. W. Biggs
J. E. Gibson

SPECIFICATIONS FOR CLEAN BITUMINOUS COAL

** Sponsor body: American Institute of Mining and Metallurgical Engineers*

R. A. Sherman (E. L. Lindseth, *Alternate*)

SPECIFICATIONS FOR FUEL OILS

** Sponsor body: American Society for Testing Materials*

W. H. Butler
Harte Cooke
H. W. Dow
L. H. Morrison
Lee Schneitter
Denistoun Wood

SPECIFICATIONS FOR MATERIALS FOR USE IN MANUFACTURE OF SPECIAL TRACKWORK

** Sponsor body: American Transit Association*

W. R. Hulbert

SPECIFICATIONS FOR AND RECOMMENDED PRACTICE IN THE USE OF WIRE ROPE FOR MINES

** Sponsor body: American Mining Congress*

J. L. Harrington

SPECIFICATIONS FOR SIEVES FOR TESTING PURPOSES

** Sponsor bodies: American Society for Testing Materials and National Bureau of Standards*

D. McM. Blackburn

SPECIFICATIONS FOR TOOL STEEL

Subcommittee No. XIV of A.S.T.M. Committee A1 on Steel

O. W. Boston
C. M. Inman

VOLUME WATER HEATING

Sponsor body: American Gas Association

Mark Resek

Power Test Codes Technical Committees

(*Personnel of Standing Committee, p.* RI-2)

(1) GENERAL INSTRUCTIONS

Appointed December, 1918

W. H. Kavanaugh, *Chairman*
A. M. Greene, Jr.
C. F. Hirshfeld
M. C. Stuart

(2) DEFINITIONS AND VALUES

Appointed December, 1918
Reorganized, 1936

R. J. S. Pigott, *Chairman*
L. J. Briggs
W. F. Davidson
S. L. Kerr
A. L. Kimball
L. S. Marks
F. G. Philo
J. C. Smallwood
P. W. Swain
A. C. Wood

(3) FUELS

Appointed December, 1918

W. J. Wohlenberg, *Chairman*
E. G. Bailey
B. L. Boye
L. P. Breckenridge
H. W. Brooks
S. B. Flagg
D. M. Myers
F. G. Philo
G. S. Pope
C. R. Richards
E. B. Ricketts
F. M. Rogers
E. X. Schmidt
Nicholas Stahl
E. N. Trump

(4) STATIONARY STEAM-GENERATING UNITS

Appointed December, 1918

E. R. Fish, *Chairman*
C. U. Savoye, *Secretary*
A. D. Bailey
Alfred Iddles
E. B. Powell
E. B. Ricketts

(5) RECIPROCATING STEAM ENGINES

Appointed December, 1918
Reappointed, 1931

A. G. Christie, *Chairman*
Harte Cooke
K. S. M. Davidson
Herman Diederichs
Henrik Greger
Thomas Hall
J. A. Hunter
H. G. Mueller
B. V. E. Nordberg
J. F. M. Patitz
A. V. Saharoff
A. G. Whitting
J. C. Workman

(6) STEAM TURBINES

Appointed December, 1918

C. H. Berry, *Chairman*
I. E. Moultrop, *Secretary*
O. D. H. Bentley
W. E. Caldwell
A. G. Christie
Hans Dahlstrand
V. M. Frost
A. E. Grunert
Francis Hodgkinson
S. A. Moss
R. O. Muller
T. E. Purcell
C. C. Thomas

(7) RECIPROCATING STEAM-DRIVEN DISPLACEMENT PUMPS

Appointed December, 1918

R. D. Hall, *Chairman*
C. H. Anderson
E. H. Brown
J. N. Chester
J. E. Gibson
G. L. Kollberg
M. B. MacNeille
D. W. Mead
L. A. Quayle

(8) CENTRIFUGAL AND ROTARY PUMPS

Appointed December, 1918
Reorganized, 1936

M. B. MacNeille, *Chairman*
H. E. Beckwith
W. B. Gregory
L. F. Moody
Arvid Peterson
F. H. Rogers
W. C. Rudd
Max Spillman
W. M. White
I. A. Winter

(9) DISPLACEMENT COMPRESSORS AND BLOWERS

Appointed December, 1918
Reorganized, 1935

Paul Diserens, *Chairman*
G. T. Felbeck
J. F. Huvane
R. M. Johnson
J. F. D. Smith

(10) CENTRIFUGAL AND TURBO-COMPRESSORS AND BLOWERS

Appointed December, 1918
Reappointed, 1929

A. T. Brown, *Chairman*
E. L. Anderson
C. A. Booth
W. H. Carrier
Thomas Chester
L. E. Day
E. S. Dean
Z. G. Deutsch
S. H. Downs
P. E. Good
J. J. Grob
H. F. Hagen
Paul Hoffman
H. D. Kelsey
A. L. Kimball
L. S. Marks
Arvid Peterson
H. F. Schmidt
M. C. Stuart

(11) COMPLETE STEAM POWER PLANTS

Appointed December, 1918
Reappointed, 1933

F. M. Van Deventer, *Chairman*
D. S. Wegg, *Secretary*
W. F. Davidson
C. H. Fellows
R. A. Foresman
V. M. Frost
W. W. Johnson
E. W. Norris
H. S. Whiton

(12) CONDENSERS, WATER HEATING, AND COOLING EQUIPMENT

Appointed December, 1918

G. A. Orrok, *Chairman*
P. J. Hardie, *Secretary*
C. H. Baker, Jr.
R. N. Ehrhart
J. F. Grace
D. W. R. Morgan
J. J. Mullan
H. B. Reynolds
P. E. Reynolds

(13) REFRIGERATING SYSTEMS

Appointed December, 1918

G. A. Horne, *Chairman*
G. B. Bright
N. H. Hiller
G. T. Voorhees

(14) EVAPORATING APPARATUS

Appointed December, 1918

E. N. Trump, *Chairman*
B. N. Bump
E. A. Newhall
H. L. Parr
L. C. Rogers

(15) STEAM LOCOMOTIVES

Appointed December, 1918

E. C. Schmidt, *Chairman*
W. F. Kiesel, Jr.
H. B. Oatley
G. E. Rhoads
L. K. Sillcox
W. E. Woodard

(16) GAS PRODUCERS

Appointed December, 1918

R. H. Fernald
C. D. Smith
H. F. Smith

(17) INTERNAL-COMBUSTION ENGINES

Appointed December, 1918
Reappointed, 1928

Max Rotter, *Chairman*
Harte Cooke
L. B. Jackson
B. V. E. Nordberg
J. H. Suter

(18) HYDRAULIC PRIME MOVERS

Appointed December, 1918
Reappointed, 1931

E. C. Hutchinson, *Chairman*
C. M. Allen
H. L. Doolittle
W. F. Durand
N. R. Gibson
J. P. Growdon
T. H. Hogg
D. J. McCormack
L. F. Moody
R. V. Terry
W. M. White

(19) INSTRUMENTS AND APPARATUS

Appointed December, 1918

C. F. Hirshfeld, *Chairman*
W. A. Carter, *Secretary*
C. M. Allen
E. G. Bailey
H. S. Bean
L. J. Briggs
C. R. Cary
J. D. Davis
R. E. Dillon
F. M. Farmer
J. B. Grumbein
W. W. Johnson
W. H. Kenerson
E. S. Lee
E. L. Lindseth
Osborn Monnett
S. A. Moss
R. J. S. Pigott
E. B. Ricketts
W. A. Sloan
R. B. Smith

(20) SPEED-RESPONSIVE GOVERNORS

Appointed December, 1921

Francis Hodgkinson, *Chairman*
Harte Cooke
J. F. M. Patitz
F. H. Rogers

(21) DUST SEPARATING APPARATUS

Appointed October, 1934

M. D. Engle, *Chairman*
Ollison Craig, *Secretary*
E. L. Anderson
A. D. Bailey
H. H. Bubar
W. G. Christy
H. O. Croft
J. M. DallaValle
Philip Drinker
J. W. Fehnel
H. F. Hagen
P. H. Hardie
C. W. Hedberg
J. H. Leech
H. E. Macomber
H. B. Meller
H. C. Murphy
B. F. Tillson

A.S.M.E. Representatives on Other Committees

See also A.S.M.E. Representatives on Other Activities, page RI-29

DEVELOPMENT OF DEFINITIONS FOR THE NET CALORIFIC VALUE AND GROSS CALORIFIC VALUE OF FUELS

Sponsor body: American Society for Testing Materials

W. J. Wohlenberg

COMMITTEE ON REDEFINING SO-CALLED STANDARD TON OF REFRIGERATION

Sponsor body: American Society of Refrigerating Engineers

G. B. Bright

Safety Technical Committees

(*Personnel of Standing Committee, p.* RI-2)

SAFETY CODE FOR MECHANICAL POWER-TRANSMISSION APPARATUS

* *Joint sponsorship with the International Association of Industrial Accident Boards and Commissions, National Bureau of Casualty and Surety Underwriters. Sectional Committee organized February, 1921*

A.S.M.E. Members (Total personnel, 35)

† C. B. Auel, *Chairman*
P. G. Rhoads, *Temporary Secretary*
† L. A. DeBlois
C. C. Foster
(W. M. Graff, *Alternate*)
W. J. Hamilton
† G. M. Naylor
W. W. Nichols
W. S. Paine
† D. C. Wright
(† G. N. VanDerhoef, *Alternate*)

Subcommittee Chairmen

No. 1 on Detail Classification of Belts
No. 2 on Modification of Rule 223 for Cone Pulley Belts
No. 3 on Mechanical Power Control, W. M. Graff
No. 4 on Use of ASA Code versus State Codes, L. A. DeBlois
No. 5 on Statistics on Place of Occurrence of Accidents

SAFETY CODE FOR ELEVATORS

* *Joint Sponsorship with the American Institute of Architects and the National Bureau of Standards. Sectional Committee organized November, 1922*

A.S.M.E. Members (Total personnel, 42)

O. P. Cummings, *Vice-Chairman*
C. R. Callaway
† D. L. Holbrook
† Bassett Jones
D. L. Lindquist
† N. O. Lindstrom
J. J. Matson
J. C. McCabe
M. B. McLauthlin
W. S. Paine

Subcommittee Chairmen

Research, Recommendations and Interpretations, D. J. Purinton
Inspectors' Handbook, K. A. Colahan
Elevator Systems Safe Against Fire, W. S. Paine
Interlocks and Hoistway Enclosures, B. Jones

SAFETY CODE ON COMPRESSED AIR MACHINERY AND EQUIPMENT

* *Joint sponsorship with the American Society of Safety Engineers—Engineering Section, National Safety Council. Sectional Committee organized May, 1923*

A.S.M.E. Members (Total personnel, 25)

D. L. Royer, *Chairman*
H. D. Edwards
W. M. Graff
W. J. Graves
† H. H. Judson

SAFETY CODE FOR CONVEYORS AND CONVEYING MACHINERY

* *Joint sponsorship with the National Bureau of Casualty and Surety Underwriters. Sectional Committee organized November, 1925*

A.S.M.E. Members (Total personnel, 44)

W. J. Graves
F. V. Hetzel
† M. A. Kendall
W. S. Paine
C. G. Pfeiffer
D. L. Royer
(W. M. Graff, *Alternate*)
† William Staniar
G. R. Wadleigh
J. G. Wheatley

† Official A.S.M.E. representatives serving on this committee.

SUBCOMMITTEE CHAIRMEN

No. 1 on All Types of Chain Conveyors and Elevators and Also Cable Flight Conveyors Omitting Track Scraper Conveyors
No. 2 on Belt Conveyors and Belt Elevators Including Steel Belt
No. 3 on Gravity Conveyors and Chutes, Live Roll Conveyors, C. A. PAUL
No. 4 on Spiral and Track or Scraper Conveyors, H. DEVERELL
No. 5 on Cable Conveyors, H. A. ROE
No. 6 on Air, Steam or Liquid Conveyors, J. J. MCNULTA

SAFETY CODE FOR CRANES, DERRICKS, AND HOISTS

** Joint sponsorship with U. S. Navy Department, Bureau of Yards and Docks. Sectional Committee organized November, 1926*

A.S.M.E. Members (Total personnel, 66)

B. F. TILLSON, *Secretary*
J. F. HOWE
W. D. KELLER
† LEWIS PRICE
F. H. SCHWERIN
† R. H. WHITE
H. L. WHITTEMORE

SUBCOMMITTEE CHAIRMEN

No. 1 on Overhead and Gantry Cranes, R. H. WHITE
No. 2 on Locomotive and Tractor Cranes, H. H. VERNON
No. 3 on Derricks and Hoists, L. PRICE
No. 4 on Miscellaneous Equipment for Cranes and Hoists (Slings, Chains and Hooks, Wire Rope and Attachments, Sheaves and Pulleys), L. W. HOPKINS
No. 5 on Jacks, E. W. CARUTHERS

AIRCRAFT SAFETY AND INSPECTION

A.S.M.E. Committee organized April, 1931

A.S.M.E. Members (Total personnel, 6)

JEROME LEDERER, *Chairman*
ALEXANDER KLEMIN

A.S.M.E. Representatives on Other Safety Committees

See also A.S.M.E. Representatives on Other Activities, page RI-29

SAFETY CODE FOR ABRASIVE WHEELS

** Sponsor bodies: Grinding Wheel Manufacturers Association of United States and Canada, and International Association of Industrial Accident Boards and Commission*

W. B. GARDINER

SAFETY CODE FOR AERONAUTICS

** Sponsor body: Society of Automotive Engineers*

(To be appointed)

SAFETY CODE FOR AMUSEMENT PARKS

** Sponsor bodies: National Association of Amusement Parks, and National Bureau of Casualty and Surety Underwriters*

G. P. SMITH, JR.

SAFETY CODE FOR CONSTRUCTION WORK

** Sponsor bodies: American Institute of Architects and National Safety Council*

(To be appointed)

COOPERATION WITH OTHER ENGINEERING SOCIETIES

Sponsor body: American Society of Safety Engineers

H. L. MINER

A.S.A. SAFETY CODE CORRELATING COMMITTEE

T. A. WALSH, JR. (H. H. JUDSON, *Alternate*)

SAFETY CODE FOR EXHAUST SYSTEMS

** Sponsor body: International Association of Industrial Accident Boards and Commissions*

J. C. HARDIGG (E. H. DECONINGH, *Alternate*)

SAFETY CODE FOR FLOOR AND WALL OPENINGS, RAILINGS, AND TOE BOARDS

** Sponsor body: National Safety Council*

WILLIAM COLLINS

SAFETY CODE FOR FORGING AND HOT METAL STAMPING

** Sponsor bodies: American Drop Forging Institute and National Safety Council*

O. F. LUCKENBACH
C. F. PARK

SAFETY CODE ON COLORS FOR IDENTIFICATION OF GAS MASK CANISTERS

** Sponsor body: National Safety Council*

L. C. LICHTY

SAFETY CODE FOR LADDERS

** Sponsor body: National Safety Council*

W. T. HATCH

SAFETY CODE FOR LAUNDRY MACHINERY AND OPERATION

** Sponsor bodies: Laundry Owners National Association, International Association of Governmental Labor Officials and National Association of Mutual Casualty Companies*

E. J. CARROLL

SAFETY CODE FOR LIGHTING FACTORIES, MILLS, AND OTHER WORKS PLACES

** Sponsor body: Illuminating Engineering Society*

L. A. BLACKBURN

SAFETY CODE FOR LOGGING AND SAWMILL MACHINERY

** Sponsor body: National Bureau of Standards*

J. H. DICKINSON

LOW VOLTAGE ELECTRICAL HAZARD

** Special Committee of the American Society of Safety Engineers—Engineering Section, National Safety Council*

J. P. JACKSON

SAFETY CODE FOR MECHANICAL REFRIGERATION

** Sponsor body: American Society of Refrigerating Engineers*

O. A. ANDERSON
CROSBY FIELD
W. F. JONES
(A. W. OAKLEY, *Alternate to all A.S.M.E. Representatives*)

SAFETY CODE FOR PAPER AND PULP MILLS

** Sponsor body: National Safety Council*

R. L. WELDON

SAFETY CODE FOR POWER PRESSES, AND FOOT AND HAND PRESSES

** Sponsor body: National Safety Council*

E. E. BARNEY

SAFETY CODE FOR PREVENTION OF DUST EXPLOSIONS

** Sponsor bodies: National Fire Protection Association and U. S. Department of Agriculture*

J. H. MORROW
R. M. FERRY

SAFETY CODE FOR PROTECTION OF HEADS, EYES AND RESPIRATORY ORGANS OF INDUSTRIAL WORKERS

** Sponsor body: National Bureau of Standards*

T. A. Walsh, Jr. (T. F. Hatch, *Alternate*)

SAFETY CODE FOR PROTECTION OF INDUSTRIAL WORKERS IN FOUNDRIES

** Sponsor bodies: American Foundrymen's Association and National Founders Association*

H. M. Lane

SAFETY CODE FOR RUBBER MACHINERY

** Sponsor bodies: National Safety Council and International Association of Industrial Accident Boards and Commissions*

(To be appointed)

SPECIFICATIONS AND METHODS OF TEST FOR SAFETY GLASS

** Sponsor bodies: National Bureau of Casualty and Surety Underwriters and National Bureau of Standards*

T. A. Walsh, Jr.

SAFETY CODE FOR TEXTILES

** Sponsor body: National Safety Council*

G. L. Warfield

SAFETY CODE FOR UNDERGROUND POWER TRANSMISSION AND POWER EQUIPMENT FOR METAL MINES

** Sponsor body: American Mining Congress, National Standardization Division*

(To be appointed)

SAFETY CODE FOR VENTILATION

** Sponsor body: American Society of Heating and Ventilating Engineers*

P. A. McKittrick (L. H. Eggert, *Alternate*)

SAFETY CODE FOR WALKWAY SURFACES

** Sponsor bodies: American Institute of Architects and National Safety Council*

W. M. Graff

SAFETY CODE FOR WINDOW WASHING

** Sponsor body: National Safety Council*

W. G. Boyle

SAFETY CODE FOR WORK IN COMPRESSED AIR

** Sponsor body: International Association of Industrial Accident Boards and Commissions*

L. J. Eibsen

A.S.M.E. Representatives on Other Activities

See also A.S.M.E. Representatives on Other Research Committees, etc., pages RI-19, 25, 27, *and* 28

(Dates in parentheses denote expiration of terms)

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SECTION M, ENGINEERING

(To be appointed)

AMERICAN ENGINEERING COUNCIL

(One-year term)

J. H. Herron, *Chairman* W. L. Batt
L. P. Alford Paul Doty
R. E. Flanders

Alternates: Sabin Crocker, J. T. Faig, W. A. Hanley E. W. O'Brien, E. L. Ohle

AMERICAN STANDARDS ASSOCIATION

Alfred Iddles (1937) *Alternates:* V. R. Willoughby
C. B. LePage

AMERICAN YEAR BOOK CORPORATION

C. E. Davies

BUREAU OF WELDING RESEARCH

James Partington

THOMAS ALVA EDISON FOUNDATION

W. S. Finlay, Jr.

THE ENGINEERING FOUNDATION

A. E. White (1939) D. Robert Yarnall (1939)
W. H. Fulweiler (1940)

RESEARCH PROCEDURE COMMITTEE

W. H. Fulweiler (1937)

ENGINEERING HISTORY

G. A. Orrok J. W. Roe

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

NATIONAL BOARD

C. E. Davies

METROPOLITAN BOARD

Ernest Hartford, *Chairman*

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

W. L. Batt (1937) W. E. Wickenden (1938)
C. F. Hirshfeld (1939)

ENGINEERS NATIONAL RELIEF FUND

W. A. Shoudy

JOHN FRITZ MEDAL BOARD OF AWARD

A. A. Potter (1937) R. E. Flanders (1939)
Paul Doty (1938) W. L. Batt (1940)

GANTT MEDAL BOARD OF AWARD

F. E. Raymond (1937) K. H. Condit (1938)
A. F. Ernst (1939)

DANIEL GUGGENHEIM MEDAL FUND, INC.

E. E. Aldrin (1937) B. M. Woods (1938)
T. A. Morgan (1939)

JOSEPH A. HOLMES SAFETY ASSOCIATION

O. P. Hood

HOOVER MEDAL BOARD OF AWARD

S. F. Voorhees (1937) C. N. Lauer (1939)
W. H. Kenerson (1941)

INTERNATIONAL ELECTROTECHNICAL COMMISSION

U. S. NATIONAL COMMITTEE

H. N. Davis — Francis Hodgkinson — Paul Diserens

Alternates: C. Harold Berry, E. C. Hutchinson

NATIONAL BUREAU OF ENGINEERING REGISTRATION

J. H. Herron

NATIONAL FIRE WASTE COUNCIL

J. A. Neale

NATIONAL MANAGEMENT COUNCIL

J. W. Roe (1938)—H. V. Coes, *Alternate*
To be appointed (1939)—C. W. Lytle, *Alternate*
L. C. Morrow (1940)—W. H. Kushnick, *Alternate*

NATIONAL RESEARCH COUNCIL

DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH

R. C. H. Heck (1937) — W. Trinks (1939)
Bert Houghton (1938) — C. E. Davies, *Secretary, Ex-Officio*

ALFRED NOBLE PRIZE

A. M. Greene, Jr.

STUDY OF COAL

JOINT COMMITTEE WITH THE A.I.M.E.

A. D. Bailey — J. C. Hobbs
E. H. Barry — A. L. Penniman, Jr.
F. M. Gibson — E. B. Ricketts
H. Drake Harkins — E. H. Tenney

UNITED ENGINEERING TRUSTEES, INC.

To be appointed (1937) — H. A. Lardner (1938)
D. Robert Yarnall (1939)

ENGINEERING SOCIETIES MONOGRAPHS COMMITTEE

C. B. Peck — G. B. Pegram

UNWIN MEMORIAL COMMITTEE

Ambrose Swasey, *Honorary Chairman*

J. A. Goff — R. E. W. Harrison

WESTERN SOCIETY OF ENGINEERS

WASHINGTON AWARD

O. A. Leutwiler (1937) — C. B. Nolte (1938)

Awards

The following paragraphs deal with the medals, awards, scholarships, and loan funds which come within the jurisdiction of the A.S.M.E. The Society also participates with other engineering societies in a number of joint awards.

Honorary Membership, to which persons of acknowledged professional eminence are elected by unanimous vote of Council under the provisions of the By-Laws and Rules. A list of honorary members is given on page RI-33.

Life Membership, which may be conferred by the Council for distinguished service to the Society; or secured by a member by payment for an annuity in accordance with the provisions of the By-Laws.

A.S.M.E. Medal, established by the Society in 1920 to be presented, together with an engraved certificate, for distinguished service in engineering and science. May be awarded for general service in science having possible application in engineering.

Holley Medal, instituted and endowed in 1924 by George I. Rockwood, Past Vice-President of the Society, to be bestowed, together with an engraved certificate, for some great and unique act of genius of engineering nature that has accomplished a great and timely public benefit.

Worcester Reed Warner Medal, provision for which was made in the will of Worcester Reed Warner, Honorary Member of the Society, is a gold medal to be bestowed, together with an engraved certificate, on the author of the most worthy paper received, dealing with progressive ideas in mechanical engineering or efficiency in management.

Melville Medal, established in 1914 by the bequest of Rear-Admiral George W. Melville, Honorary Member and Past-President of the Society, to be presented, together with an engraved certificate, for an original paper or thesis of exceptional merit, presented to the Society for discussion and publication, to encourage excellence in papers. The medal may be presented annually.

Spirit of Saint Louis Medal, endowed by members of the Society and citizens residing in St. Louis, Mo., to be awarded for meritorious service in the field of aeronautical engineering. This medal will be awarded at the discretion of the Council of the Society at approximately three-year periods upon the recommendation of a Spirit of Saint Louis Medal Board of Award made up of six members, each appointed for a term of nine years and the terms of two members expiring at each three-year period. The St. Louis Section and the Aeronautic Division will each be responsible for the nomination of three members.

Junior Award, annual cash award of $50, established in 1914, from a fund created by Henry Hess, Past Vice-President of the Society, to be presented, together with an engraved certificate, for the best paper or thesis submitted by a Junior Member.

Student Awards, two annual cash awards of $25 each, established in 1914, from a fund created by Henry Hess, Past Vice-President of the Society, to be presented, together with engraved certificates, for the best papers or theses submitted by Student Members. The awards for 1932 and subsequent years have been given, one for undergraduate and the other for postgraduate work.

Charles T. Main Award, annual cash award of $150, established in 1919 from a fund created by Charles T. Main, Past-President of the Society, to be awarded, together with an engraved certificate, to a Student Member of the Society, for the best paper within the general subject of the influence of the profession upon public life. The exact subject is assigned by the Board of Honors and Awards, subject to the approval of the Council, and is announced each year through the Honorary Chairmen of the Student Branches.

SCHOLARSHIPS AND LOAN FUNDS

Max Toltz: Loan Fund of $15,000 established by Major Max Toltz, former member of the Council of the Society, the income to be used for assistance to Student Members.

John R. Freeman: Fund of $25,000 established in 1926 by John R. Freeman, Past-President of the Society, the income to be used for travel scholarships and research.

Woman's Auxiliary: Scholarship or Fellowship offered by the Woman's Auxiliary to the Society to assist sons and daughters of members or worthy students of mechanical engineering.

RECIPIENTS OF AWARDS

The names of the recipients of the different awards to date are given in the following lists, together with the dates of presentation, and the services or papers for which the awards were made. There were no awards for the years not listed.

A.S.M.E. Medal

1921 Hjalmar Gotfried Carlson, in recognition of the services rendered the Government because of his invention and part in the production of 20,000,000 Mark III drawn steel booster casings used principally as a component of 75-mm high-explosive shells, but also used extensively in gas shells and bombs

1922 Frederick Arthur Halsey, for his paper describing the premium system of wage payments presented before the

Society at the Providence Meeting in 1891, as the adoption of the methods there proposed has had a profound effect toward harmonizing the relations of worker and employer

1923 John Ripley Freeman, for his eminent service in engineering and manufacturing by his meritorious work in fire prevention and the preservation of property

1926 R. A. Millikan, in recognition of his contributions to science and engineering

1927 Wilfred Lewis, for his contributions to the design and construction of gear teeth

1928 Julian Kennedy, for his services and contributions to the iron and steel industry

1929 William LeRoy Emmet, for his contributions in the development of the steam turbine, electric propulsion of ships, and other power-generating apparatus

1931 Albert Kingsbury, for his research and development work in the field of lubrication

1933 Ambrose Swasey, for his contributions to the advancement of the engineering profession and for his part in the development of the turret lathe and the astronomical telescope

1934 Willis H. Carrier, in recognition of his research and development work in air-conditioning

1935 Charles T. Main, for distinguished achievements in the textile and other industries, in engineering education, and for eminent service to the engineering profession

1936 Edward Bausch, for meritorious mechanical developments in the field of optics.

Holley Medal

1924 Hjalmar Gotfried Carlson, for his inventions and processes which made possible the timely production of drawn steel booster casings for artillery ammunition, thereby aiding victory in the World War (diploma in recognition of achievements presented in 1921)

1927 Elmer Ambrose Sperry, for achievements and inventions that have advanced the naval arts, including the gyroscope that has freed navigation from the dangers of the fluctuating magnetic compass

1929 Baron Chuzaburo Shiba, for his contributions to knowledge through fundamental research, including the field of aerodynamics, by the development of ultra-rapid kinematographic methods

1934 Irving Langmuir, for his contributions to science and engineering, including the development of gas-filled incandescent lamps, thoriated filament for thermionic emission, atomic hydrogen welding, phase control operation of the thyratron tube, and fundamental research in oil films

1936 Henry Ford, for revolutionary influence through invention and practice on transportation and on mass production methods in manufacturing.

Worcester Reed Warner Medal

1933 Dexter S. Kimball, for his contributions to efficiency in management as exemplified by his recently revised "Principles of Industrial Organization" and by his many articles, engineering society papers, and public addresses

1934 Ralph E. Flanders, for his contributions to a better understanding of the relationship of the engineer to economic problems and social trends as exemplified by the many papers which he has presented

1935 Stephen Timoshenko, for his contributions to the theory of the design of elastic structures and the treatment of dynamics of moving machinery

1936 Charles M. Allen, for his early and continued hydraulic laboratory work and for the permanent value of the papers on his development of methods of testing large hydraulic turbine installations.

Melville Medal

1927 Leon P. Alford, "Laws of Manufacturing Management"

1929 Joseph W. Roe, "Principles of Jig and Fixture Practice"

1930 Herman Diederichs and William D. Pomeroy, "The Occurrence and Elimination of Surge or Oscillating Pressure in Discharge Lines From Reciprocating Pumps"

1931 Arthur E. Grunert, "Comparative Performance of a Pulverized-Coal-Fired Boiler Using Bin System and Unit System of Firing"

1932 Alexey J. Stepanoff, "Leakage Loss and Axial Thrust in Centrifugal Pumps"

1933 William E. Caldwell, "Characteristics of Large Hell Gate Direct-Fired Boiler Units"

1935 Oscar R. Wikander, "Draft-Gear Action in Long Trains"

1936 H. A. Stevens Howarth, for his paper The Loading and Friction of Thrust and Journal Bearings with Perfect Lubrication.

Spirit of Saint Louis Medal

1929 Daniel Guggenheim, founder of the Guggenheim Fund for the Promotion of Aeronautics

1932 Paul Litchfield, for his work in encouraging and sponsoring airship design and construction in this country

1935 Will Rogers, for his splendid, constructive, and unselfish work in the achievement of aviation, and the building up of public confidence in aviation through his articles in the press, over the radio, and from the speaker's platform.

Junior Award

1915 Ernest O. Hickstein, "Flow of Air Through Thin Plate Orifices"

1916 L. M. McMillan, "The Heat Insulating Properties of Commercial Steam-Pipe Coverings"

1919 E. D. Whalen, "Properties of Airplane Fabrics"

1921 S. Logan Kerr, "Moody Ejector Turbine"

1922 R. H. Heilman, "Heat Losses From Bare and Covered Wrought-Iron Pipe at Temperatures Up to 800 Degrees Fahrenheit"

F. L. Kallam, "Preliminary Report on the Investigation of the Thermal Conductivity of Liquids"

1923 S. S. Sanford and S. Crocker, "The Elasticity of Pipe Bends"

1924 R. H. Heilman, "Heat Losses Through Insulating Material"

1925 Gilbert S. Schaller, "An Investigation of Seattle as a Location for a Synthetic Foundry Industry"

1927 Wm. M. Frame, "Stresses Occurring in the Walls of an Elliptical Tank Subjected to Low Internal Pressure"

1928 M. D. Aisenstein, "A New Method of Separating the Hydraulic Losses in a Centrifugal Pump"

1929 Arthur M. Wahl, "Stresses in Heavy, Closely Coiled Helical Springs"

1930 Ed Sinclair Smith, Jr., "Quantity-Rate Fluid Meters"

1931 M. K. Drewry, "Radiant-Superheater Developments"

1932 Edmond M. Wagner, "Frictional Resistance of a Cylinder Rotating in a Viscous Fluid Within a Coaxial Cylinder"

1933 Townsend Tinker, "Surface Condenser Design and Operating Characteristics"

1934 John I. Yellott, Jr., "Supersaturated Steam"

1935 Stanley J. Mikina, "Effect of Skewing and Pole Spacing on Magnetic Noise in Electrical Machinery"

1936 Harwood F. Mullikan, Jr., "Evaluation of Effective Radiant Heating Surface and Application of the Stefan-Boltzman Law to Heat Absorption in Boiler Furnaces."

Student Award

1916 Boynton M. Green, Stanford University, "Bearing Lubrication"

Howard E. Stevens, Rensselaer Polytechnic Institute, "An Investigation of the Dynamic Pressure on Submerged Flat Plates"

M. Adam, Louisiana State University, "The Adaptability of the Internal Combustion Engine to Sugar Factories and Estates"

1917 H. R. Hammond and C. W. Holmberg, Pennsylvania State College, "Study of Surface Resistance With Glass as the Transmission Medium"

1919 C. F. Leh and F. G. Hampton, Stanford University, "An Experimental Investigation of Steel Belting"

W. E. Helmick, Stanford University, "An Experimental Investigation of Steel Belting"

1920 Howard G. Allen, Cornell University, "Wire Stitching Through Paper"

1921 Karl H. White, University of Kansas, "Forces in Rotary Motors"

Richard H. Morris and Albert J. R. Houston, University of California, "A Report Upon an Investigation of the Herschel Type of Improved Weir"

1923 CHARLES F. OLMSTEAD, University of Minnesota, "Oil Burning for Domestic Heating"
H. E. DOOLITTLE, University of California, "The Integrating Gate: A Device for Gaging in Open Channels"
1924 GEORGE STUART CLARK, Stanford University, "Two Methods Used for the Determination of the Gasoline Content of Absorption Oils in Absorption Plants"
L. J. FRANKLIN AND CHARLES H. SMITH, Stanford University, "The Effect of Inaccuracy of Spacing on the Strength of Gear Teeth"
1925 HARRY PEASE COX, JR., Rensselaer Polytechnic Institute, "A Study of the Effect of End Shape on the Towing Resistance of a Barge Model"
W. S. MONTGOMERY, JR., AND E. RAY ENDERS, JR., Pennsylvania State College, "Some Attempts to Measure the Drawing Properties of Metals"
1926 R. E. PETERSON, University of Illinois, "An Investigation of Stress Concentration by Means of Plaster of Paris Specimens"
CECIL G. HEARD, University of Toronto, "Pressure Distribution Over U. S. A. 27 Aerofoil With Square Wing Tips Model Tests"
1927 ALFRED H. MARSHALL, Princeton, "Evaporative Cooling"
ROGER IRMIN EBY, University of Washington, "Measurement of the Angular Displacement of Flywheels"
1928 CLARENCE C. FRANCK, Johns Hopkins University, "Condition Curves and Reheat Factors for Steam Turbines"
1929 FRANK VERNON BISTROM, University of Washington, "An Investigation of a Rotary Pump"
WILLIAM WALLACE WHITE, University of Washington, "An Investigation of a Rotary Pump"
1930 GERARD EDEN CLAUSSEN, Polytechnic Institute of Brooklyn, "High-Temperature Oxidation of Steel"
HAROLD L. ADAMS AND RICHARD L. STITH, University of Washington, "A Wind Tunnel for Undergraduate Laboratory Experiments"
1931 JULES PODNOSSOFF, Polytechnic Institute of Brooklyn, "Pressure and Energy Distribution in Multi-Stage Steam Turbines Operating Under Varying Conditions"
1932 H. E. FOSTER, JR., University of Tennessee, "Factors Affecting Spray Pond Design" (Undergraduate Award)
WILLIAM A. MASON, Stanford University, "An Experimental Investigation of the Flame Propagation in Internal-Combustion Engines" (Postgraduate Award)
1933 HUGO V. CORDIANO, Polytechnic Institute of Brooklyn, "Thermal Analysis of Lithium-Magnesium System of Alloys" (Undergraduate Award)
JAMES A. OSTRAND, JR., Princeton University, "Sudden Enlargement in the Open Channel" (Postgraduate Award)
1934 H. REYNOLDS HUDSON, Georgia School of Technology, "Dynamic Balance and Functional Utility Applied to Automotive Design" (Undergraduate Award)
1935 CHARLES P. BACHA, Rutgers University, "The Behavior of Metals Subjected to Combined Stress" (Postgraduate Award)
ROBERT W. BEAL, Oregon State College, "Do Lubricating Oils Wear Out?" (Undergraduate Award)
1936 LEON B. STINSON, Oklahoma Agricultural and Mechanical College, "Polymerized Motor Fuels; Their Economic Significance" (Undergraduate Award)
DEWITT D. BARLOW, JR., Princeton University, "The Critical Speeds of Lateral Vibrations of Shafts with Gyroscopic Effect" (Postgraduate Award).

CHARLES T. MAIN AWARD

1925 CLEMENT R. BROWN, Catholic University of America. Subject: "The Influence of the Locomotive on the Unity of the United States"
1926 W. C. SAYLOR, Johns Hopkins University. Subject: "The Effect of the Cotton Gin Upon the History of the United States During Its First Seventy Years"
1927 No award. Subject: "Scientific Management and Its Effect Upon the Industries"
1928 ROBERT M. MEYER, Newark College of Engineering. Subject: "Scientific Management and Its Effect Upon Manufacturing"
1929 No award. Subject: "The Influence of Engineering on Farm Production"
1930 JULES PODNOSSOFF, Polytechnic Institute of Brooklyn. Subject: "The Value of the Safety Movement in the Industries"
1931 ROBERT E. KLISE, University of Michigan. Subject: "Interchangeability—Its Development and Significance in Industry"
1932 MARSHALL ANDERSON, University of Michigan. Subject: "Apprenticeship and Vocational Training"
1933 GEORGE D. WILKINSON, JR., Newark College of Engineering. Subject: "Progress in the Prevention of Smoke and Atmospheric Pollution"
1934 PHILIP P. SELF, Colorado State College. "Air Conditioning—Its Practicability and Relation to Public Welfare"
1935 G. LOWELL WILLIAMS, Lafayette College. Subject: "Coordinated Transportation—An Economic Comparison of Railroad, Bus, Truck, Water, and Air Transportation for Long and Short Haul"
1936 No award. Subject: "Development in the Generation and Distribution of Power and Their Effect upon the Consumer."

FREEMAN TRAVEL SCHOLARSHIP

1927 HERBERT N. EATON
1928 BLAKE R. VAN LEER
1929 ROBERT T. KNAPP
1931 REGINALD WHITAKER
1932 G. ROSS LORD
1933, 1934 H. J. CASEY
1935, 1936 VICTOR L. STREETER

Honorary Members

HONORARY MEMBERS IN PERPETUITY

Alexander Lyman Holley, Founder of the Society. Died 1882.

John Edson Sweet, Founder of the Society. Died 1916.

Henry Rossiter Worthington, Founder of the Society. Died 1880.

DECEASED HONORARY MEMBERS

	Elected	Died
Horatio Allen	1880	1889
Sir William Arrol	1905	1913
Sir John Audley Frederick Aspinall	1911	1937
William Wallace Atterbury	1925	1935
Sir Benjamin Baker	1886	1907
Johann Bauschinger	1884	1893
Sir Henry Bessemer	1891	1898
Sir Frederick Joseph Bramwell	1884	1903
John Alfred Brashear	1908	1920
Gustave Canet	1900	1908
Andrew Carnegie	1907	1919
Daniel Kinnear Clark	1882	1896
Rudolph Julius Emmanuel Clausius	1882	1888
Sir John Goode	1889	1892
Peter Cooper	1882	1883
Carl Gustaf Patrick de Laval	1912	1913
Rudolph Diesel	1912	1913
James Dredge	1886	1906
Victor Dwelshauvers-Dery	1886	1913
Thomas Alva Edison	1904	1931
Alexandre Gustave Eiffel	1889	1923
Marshal Ferdinand Foch	1921	1929
Sir Charles Douglas Fox	1900	1921
John Ripley Freeman	1932	1932
John Fritz	1900	1913
Major-General George Washington Goethals	1917	1928
Franz Grashof	1884	1893
Rear-Admiral Robert Stanislaus Griffin	1920	1933
Otto Hallauer	1882	1883
Charles Haynes Haswell	1905	1907
Friedrich Gustav Herrmann	1884	1907
Gustav Adolph Hirn	1882	1890
Joseph Hirsch	1889	1901
Ira N. Hollis	1928	1930
Robert Woolston Hunt	1920	1923
Benjamin Franklin Isherwood	1894	1915
Henri Léauté	1891	1916
Erasmus Darwin Leavitt	1915	1916
Henri Le Chatelier	1927	1936
Anatole Mallet	1912	1919
Charles H. Manning	1913	1919
Rear-Admiral George Wallace Melville	1910	1912
The Honorable Sir Charles Algernon Parsons	1920	1931
Charles Talbot Porter	1890	1910
Auguste C. E. Rateau	1919	1930
Sir Edward J. Reed	1882	1906
Franz Reuleaux	1882	1905
Calvin Winsor Rice	1931	1934
Palmer C. Ricketts	1931	1934
Henri Adolphe-Eugene Schneider	1882	1898
C. William Siemans	1882	1883
Viscount Ei-ichi Shibusawa	1929	1931
Henry Robinson Towne	1921	1924
Henri Tresca	1882	1885
William Cawthorne Unwin	1898	1933
Oskar von Miller	1912	1934
Francis A. Walker	1886	1897
Worcester Reed Warner	1925	1929
George Westinghouse	1897	1914
Sir William Henry White	1900	1913
Sir Alfred Fernandez Yarrow	1914	1932

LIVING HONORARY MEMBERS

	Elected
Hutchinson I. Cone	1936
Mortimer Elwyn Cooley	1928
Alex Dow	1936
William Frederick Durand	1934
Charles de Fréminville	1919
Nathanael Greene Herreshoff	1921
Herbert Clark Hoover	1925
David Schenck Jacobus	1934
Masawo Kamo	1929
George A. Orrok	1936
Grande Ufficiale Ing. Pio Perrone	1920
Charles M. Schwab	1918
Ambrose Swasey	1916
Elihu Thomson	1930
Samuel Matthews Vauclain	1920
Right Honorable Lord Weir	1920
Orville Wright	1918

Past-Presidents

A list of past vice-presidents, managers, treasurers, and secretaries will be found in the 1930 Record and Index, pages 10-12. Dates in parentheses denote year of death.

Alexander Lyman Holley, *Chairman of the Preliminary Meeting for Organization of The American Society of Mechanical Engineers* (1882)

1880–1882	Robert Henry Thurston (1903)
1883	Erasmus Darwin Leavitt (1916)
1884	John Edson Sweet (1916)
1885	Josephus Flavius Holloway (1896)
1886	Coleman Sellers (1907)
1887	George H. Babcock (1893)
1888	Horace See (1909)
1889	Henry Robinson Towne (1924)
1890	Oberlin Smith (1926)
1891	Robert Woolston Hunt (1923)
1892	Charles Harding Loring (1907)
1893–1894	Eckley Brixton Coxe (1895)
1895	Edward F. C. Davis (1895)
1895	Charles Ethan Billings (1920)
1896	John Fritz (1913)
1897	Worcester Reed Warner (1929)
1898	Charles Wallace Hunt (1911)
1899	George Wallace Melville (1912)
1900	Charles Hill Morgan (1911)
1901	Samuel T. Wellman (1919)
1902	Edwin Reynolds (1909)
1903	James Mapes Dodge (1915)
1904	Ambrose Swasey
1905	John Ripley Freeman (1932)
1906	Frederick Winslow Taylor (1915)
1907	Frederick Remsen Hutton (1918)
1908	Minard Lafever Holman (1925)
1909	Jesse Merrick Smith (1927)
1910	George Westinghouse (1914)
1911	Edward Daniel Meier (1914)
1912	Alexander Crombie Humphreys (1927)
1913	William Freeman Myrick Goss (1928)
1914	James Hartness (1934)
1915	John Alfred Brashear (1920)
1916	David Schenck Jacobus
1917	Ira Nelson Hollis (1930)
1918	Charles Thomas Main
1919	Mortimer Elwyn Cooley
1920	Fred J. Miller
1921	Edwin S. Carman
1922	Dexter Simpson Kimball
1923	John Lyle Harrington
1924	Frederick Rollins Low (1936)
1925	William Frederick Durand
1926	William Lamont Abbott
1927	Charles M. Schwab
1928	Alex Dow
1929	Elmer Ambrose Sperry (1930)
1930	Charles Piez (1933)
1931	Roy V. Wright
1932	Conrad N. Lauer
1933	A. A. Potter
1934	Paul Doty
1935	Ralph E. Flanders
1936	William L. Batt

Index to Society Records, Part 1

The page numbers in this section are preceded by the letters "RI," which are omitted in the following index.

INDEX TO COUNTRIES

ALPHABETICAL LIST OF MEMBERS

A

Aarflot, M. G.......New York, N. Y.
Aaron, H. R.................
Singapore, Malay Penin.
Aaron, R. H.....Los Angeles, Calif.
Abadjieff, I. V......Worcester, Mass.
Abbatiello, A. A..Schenectady, N. Y.
Abbe, R. H......Newburyport, Mass.
Abbey, H. G..........New York, N. Y.
Abbott, C. C........Pittsfield, Mass.
Abbott, J., Jr.........Bogota, N. J.
Abbott, R. G.........Anderson, Ind.
Abbott, S................Dallas, Tex.
Abbott, W. G., Jr.....Wilton, N. H.
Abbott, W. L...........Chicago, Ill.
Abdun-Nur, E. A.......Denver, Colo.
Abe, K................Tokyo, Japan
Abe, P. A...............Sidney, Ohio
Abel, C. R...........Camden, N. J.
Abell, H. C.........New Orleans, La.
Abendschein, E. J.Niagara Falls, N. Y.
Abercrombie, J. H......Reigate, Eng.
Abercrombie, W. T., Jr........
Burlington, N. J.
Abcozbeeb, A. E....Cambridge, Mass.
Aborn, G. P...........Waban, Mass.
Abrahamson, E. W.....Buffalo, N. Y.
Abrahamson, W. A....Brooklyn, N. Y.
Abrams, C. ....Newberry, S. C.
Abrams, H. T..........Orange, N. J.
Abrams, V. R.......Elizabeth, N. J.
Acheson, A. R........Syracuse, N. Y.
Acheson, H. A.....Port Huron, Mich.
Acheson, J. M......New York, N. Y.
Ackart, E. G.......Wilmington, Del.
Acker, G. H.........Cleveland, Ohio
Acker, S. H.........Nashville, Tenn.
Ackerman, A. A......Cleveland, Ohio
Ackerman, F..........St. Louis, Mo.
Ackerman, W. L.........Peoria, Ill.
Adair, F. M.........Manhattan, Kan.
Adair, J. G.......Washington, D. C.
Adamaszek, J.........Detroit, Mich.
Adams, A. C.........Cleveland, Ohio
Adams, A. H.......New York, N. Y.
Adams, C. A..........Belmont, Mass.
Adams, C. R............S. Bend, Ind.
Adams, C. S..........Oakland, Calif.
Adams, C. V............Chicago, Ill.
Adams, E. E............Chicago, Ill.
Adams, E. T......Long Beach, Calif.
Adams, F. E.........Berkeley, Calif.
Adams, F. S......Washington, D. C.
Adam, F. W...........Madison, Me.
Adams, H. B., Jr..Bauru, Brazil, S. A.
Adams, H. E......S. Norwalk, Conn.
Adams, H. H............Chicago, Ill.
Adams, H. L...........Seattle, Wash.
Adams, J. E...Elmhurst, L. I., N. Y.
Adams, J. Q......Schenectady, N. Y.
Adams, L. D...........Detroit, Mich.
Adams, O. P.........McKeesport, Pa.
Adams, P. H.........Northfield, Vt.
Adams, S.............Cleveland, Ohio
Adams, W. H..........Hondo, Calif.
Adamson, K.....................
Aberdeen Proving Ground, Md.
Addams, H..........New York, N. Y.
Addicks, L...............Bel Air, Md.
Addicks, M. C.........St. Louis, Mo.
Adelman, A.......Washington, D. C.
Adelson, J. S........Cleveland, Ohio
Adie, J. A...Point Pleasant, W. Va.
Adler, A. A.........Arlington, N. J.
Adolphson, H. B.....Plainfield, N. J.
Adolphson, J. F.......St. Louis, Mo.
Adolphson, R. T.......St. Louis, Mo.
Adolphus, K. B. H.
Montreal, Que., Can.
Adwany, R. K.......Cleveland, Ohio
Adzima, G. R.......Westfield, Mass.
Aeberli, A.......Toronto, Ont., Can.
Aerni, A. A..........Cleveland, Ohio
Agashe, K. M..........Baroda, India
Agee, H. H.............Newark, N. J.
Agner, O. B........Philadelphia, Pa.
Agnew, T. C......Toronto, Ont., Can.
Agrell, C. F........Montgomery, Ala.
Agronin, T..........Haverhill, Mass.
Ahara, E. V...........Rumford, Me.
Ahlqvist, H........New York, N. Y.
Ahrens, C..........New York, N. Y.
Ahrens, G. C.......Ellenville, N. Y.
Ainsworth, J. R.....Wilmerding, Pa.
Airey, J..........Ann Arbor, Mich.
Airston, A. J.......Philadelphia, Pa.
Aisenstein, M. D..Moscow, U. S. S. R.
Aitchison, C. S....Chevy Chase, Md.
Aitken, M............Seattle, Wash.
Aitken, S...........New York, N. Y.
Akabane, S..........New York, N. Y.
Akins, C. M......Minneapolis, Minn.
Albanese, M...........Passaic, N. J.
Alberga, G. H........Clinton, Mass.
Albert, C. D...........Ithaca, N. Y.
Alberti, A..............Terni, Italy
Alberts, M. A.........Brooklyn, N. Y.
Albl, F. O...........Cleveland, Ohio
Albrecht, A. J......Philadelphia, Pa.
Albrecht, G. F............Saco, Me.
Albridge, K. P.........Boston, Mass.
Alburger, H. A.....Washington, D. C.
Alcott, E. A.....Huntington, W. Va.
Alden, C. R...........Detroit, Mich.
Alden, J. D.....Asbury Park, N. J.
Alden, J. L............Chicago, Ill.
Alden, V. E...........Chicago, Ill.
Aldinger, H. K..........Atlanta, Ga.
Aldrich, B. M.......Brookings, S. D.
Aldrich, Henry E...New York, N. Y.
Aldrich, Horace E....Alexandria, Va.
Aldrich, J. G......Providence, R. I.
Aldrich, R. C......Jersey City, N. J.
Aldrich, W. H.......Cleveland, Ohio
Aldrich, W. S.........Syracuse, N. Y.
Aldridge, E. F....Toronto, Ont., Can.
Aldrin, E. E.........New York, N. Y.
Alexander, Chas. Anderson......
Rochester, N. Y.
Alexander, Chas. Anton..Toledo, Ohio
Alexander, D. H.....Belfast, Ireland
Alexander, E. E...High Bridge, N. J.
Alexander, K. O....San Bruno, Calif.
Alexander, R. I.......Frostburg, Md.
Alexander, R. M....Philadelphia, Pa.
Alexander, W., II........Chester, Pa.
Alexander, W. T.......Boston, Mass.
Alexander, W. W....Monrovia, Calif.
Alexovits, T. M.......Newark, N. J.
Alford, L. P........New York, N. Y.
Alfson, C. W.....E. Pittsburgh, Pa.
Alger, H. C............Chicago, Ill.
Alger, P. L......Schenectady, N. Y.
Algeri, D. J.........Brooklyn, N. Y.
Alimoff, W...Long Island City, N. Y.
Allan, W. T.........Harrison, N. J.
Allardice, T. B.....New York, N. Y.
Allcut, E. A.....Toronto, Ont., Can.
Allemang, H. J.........Morrison, Ill.
Allen, C. D...Lynnfield Center, Mass.
Allen, C. H...........Denver, Colo.
Allen, C. L.......State College, Pa.
Allen, C. M.........Worcester, Mass.
Allen, D. P.......Washington, D. C.
Allen, E. C..........W. Allis, Wis.
Allen, F. B.......Glen Ridge, N. J.
Allen, F. C...........Denver, Colo.
Allen, F. C., Jr.....New York, N. Y.
Allen, F. L.........Montclair, N. J.
Allen, H...............Houston, Tex.
Allen, H. A. ....Chicago, Ill.
Allen, H. M...,...........Tulsa, Okla.
Allen, J..............Baltimore, Md.
Allen, J. C.........New Castle, Pa.
Allen, J. D..........Belding, Mich.
Allen, J. F...........Cleveland, Ohio
Allen, J. M............Chicago, Ill.
Allen, LeR. V......New York, N. Y.
Allen, M. C...........Golden, Colo.
Allen, M. H., Jr.........Beeville, Tex.
Allen, M. H. P. .Johannesburg, Africa
Allen, O. F.........New York, N. Y.
Allen, P..............Allentown, Pa.
Allen, R. M.........Brooklyn, N. Y.
Allen, T. H.........Memphis, Tenn.
Allen, W............Milwaukee, Wis.
Allen, W. G.............Chicago, Ill.
Alley, K. G.........Cincinnati, Ohio
Allgaier, J. M............Joliet, Ill.
Allhusen, J...........Newark, N. J.
Alliger, W. T.........Houston, Tex.
Allingham, H. W.......London, Eng.
Allison, A. W., Jr...Pasadena, Tex.
Allison, C. O..........Atlanta, Ga.
Allison, J. M...........Hampton, Va.
Allman, W. N.......New York, N. Y.
Allner, F. A..........Baltimore, Md.
Allport, H.............Chicago, Ill.
Allspach, H. E....Charleston, W. Va.
Allstrum, L. S.......New York, N. Y.
Alman, L. C.........Brooklyn, N. Y.
Almirall, J.........New York, N. Y.
Almoian, N. A.....New York, N. Y.
Alpern, M...........Philadelphia, Pa.
Alrich H. W........New York, N. Y.
Alsberg, J.........New York, N. Y.
Alt, L. M............Lafayette, Ind.
Alt, W. O............Detroit, Mich.
Alter, H. J.College Point, L. I., N. Y.
Althouse, E. G.....Philadelphia, Pa.
Altieri, N. L..........Bayonne, N. J.
Altin, A...,,......New York, N. Y.
Alton, D. D...........Houston, Tex.
Alton, D. E.........New York, N. Y.
Altorfer, H.........Hartford, Conn.
Alves, A. L........Watertown, Conn.
Ambler, F. M........Bridgeport, Pa.
Ambrose, E. R.....Schenectady, N. Y.
Ambrose, R. B.......Pittsburgh, Pa.
Ames, A. P............Manila, P. I.
Ames, J. B.......Philadelphia, Pa.
Ames, M. R.........Syracuse, N. Y.
Amidon, L. L....Morgantown, W. Va.
Ammann, H. L......Scarsdale, N. Y.
Amneus, N. A........Oakland, Calif.
Amore, J...........Brooklyn, N. Y.
Amorosi, A. M........Jeannette, Pa.
Amorosi, G ....
Arlington, S. I., N. Y.
Amos, C. W..........Pittsburgh, Pa.
Amrein, J...........Brooklyn, N. Y.
Amstutz, J. B..........Chicago, Ill.
Amstuz, J. O............Troy, N. Y.
Anastasi, A. J........Eddystone, Pa.
Anaya, M.......San Francisco, Calif.
Anbro, G. A.......Jersey City, N. J.
Ancona, J. F.......Rochester, N. Y.
Anderegg, R. H......La Crosse, Wis.
Anders, L. H........Tuscaloosa, Ala.
Andersen, H. C...........Erie, Pa.
Anderson, A. E......Hoquiam, Wash.
Anderson, A. F......Brooklyn, N. Y.
Anderson, A. W................
Long Beach, L. I., N. Y.
Anderson, B. G......Rochester, N. Y.
Anderson, C. E......Brooklyn, N. Y.
Anderson, C. H......Cincinnati, Ohio
Anderson, C. O.......Endicott, N. Y.
Anderson, D. L.......Brooklyn, N. Y.
Anderson, D. M...Long Beach, Calif.
Anderson, E.......E. Lansing, Mich.
Anderson, E. C...Downers Grove, Ill.
Anderson, E. E..........Detroit, Mich.
Anderson, E. F................
Montevideo, Uruguay, S. A.
Anderson, E. P.......Billings, Mont.
Anderson, G. A.......New York, N. Y.
Anderson, G. E......Cleveland, Ohio
Anderson, G. F......Hazelwood, N. C.
Anderson, G. P.....New York, N. Y.
Anderson, G. W.......Tacoma, Wash.
Anderson, H.........Lansdowne, Pa.
Anderson, H. A.....Naugatuck, Conn.
Anderson, H. C.....Ann Arbor, Mich.
Anderson, H. H........St. Louis, Mo.
Anderson, H. L...........Gary, Ind.
Anderson, J. A..........Chicago, Ill.
Anderson, J. E...Schenectady, N. Y.
Anderson, J. H......Hawthorne, N. J.
Anderson, J. L........Vernon, Calif.
Anderson, J. N.....New York, N. Y.
Anderson, J. W................
Rockville Center, L. I., N. Y.
Anderson, K. B......Oakland, Calif.
Anderson, L. D..Carlsbad, New Mex.
Anderson, M.......Schenectady, N. Y.
Anderson, N. H.........London, Eng.
Anderson, N. O.......E. St. Louis, Ill.
Anderson, O. A.........Chicago, Ill.
Anderson, O. H..Hamilton, Ont., Can.
Anderson, R. C..Sparrows Point, Md.
Anderson, R. M.....Circleville, Ohio
Anderson, Richard T..Princeton, N. J.
Anderson, Robt. T..Philadelphia, Pa.
Anderson, T..........Elizabeth, N. J.
Andre, E. R........Royal Oak, Mich.
Andrei, C. .Rivoltella del Garda, Italy
Andreini, J. I.......New York, N. Y.
Andrew, J. D......New York, N. Y.
Andrew, L. R.........St. Louis, Mo.
Andrew, M. B......Fort Peck, Mont.
Andrew, P. J..S. Porcupine, Ont., Can.
Andrews, B. R......Dorchester, Mass.
Andrews, E. V.......Milwaukee, Wis.
Andrews, H. I.........London, Eng.
Andrews, J. W......New York, N. Y.
Andrews, R. M.........Ithaca, N. Y.
Andrews, R. W........Chicago, Ill.
Andrews, S. W................
Niagara Falls, Ont., Can.
Andrews, W. J........Raleigh, N. C.
Andriola, A. D........Groton, Conn.
Andrix, E. R.........Columbus, Ohio
Andrus, L. B..........S. Bend, Ind.
Angell, E. N........Baltimore, Md.
Angeloro, A........New York, N. Y.
Angier, E. H.....Framingham, Mass.
Angus, H. H....Toronto, Ont., Can.
Angus, R. W....Toronto, Ont., Can.
Angus, W. N......New York, N. Y.
Annett, E. B......Maplewood, N. J.
Annis, R. K........Asheville, N. C.
Anthony, G. C...New Rochelle, N. Y.
Anthony, G. H.......Hartford, Conn.
Anthony, J. T......Philadelphia, Pa.
Anthony, R. D.....Burlington, N. C.
Anthony, R. L....New Haven, Conn.
Antisell, F. L........Pittsburgh, Pa.
Antoniotti, H....N. Plymouth, Mass.
Antonsanti, L..........Ponce, P. R.
Antonucci, B. J....New York, N. Y.
Anuskiewicz, M. W., Jr........
Brooklyn, N. Y.
Appel, A. W........Brooklyn, N. Y.
Apperson, J. S....Schenectady, N. Y.
Applebaum, S. B....New York, N. Y.
Applegate, F. R....Kansas City, Kan.
Applegate, W........Pittsburgh, Pa.
Applegate, W. A..N. Plainfield, N. J.
Applegate, W. D.......Norwood, Pa.
Appleyard, J. S....Jamestown, N. Y.
Apps, C. H.........E. Orange, N. J.
ap Rhys Pryce, M. A...........
Pointe-a-Pierre, Trinidad
Apt, S. R......Flushing, L. I., N. Y.
Archdeacon, H. K..New York, N. Y.
Archea, W. D.......Cincinnati, Ohio
Archer, C. E.......Charleston, W. Va.
Archer, E. G.............Rome, Ga.
Archibald, F. A., Jr...........
New Rochelle, N. Y.
Archibald, F. L........Boston, Mass.
Archibald, W. D....New York, N. Y.
Arentzen, E. M........Franklin, Pa.
Arenwald, M. E......Brooklyn, N. Y.
Argyle, W. R......Marcus Hook, Pa.
Arico, L. J..........Brooklyn, N. Y.
Arkebauer, J. O....New York, N. Y.
Armacost, W. H....New York, N. Y.
Armentrout, H. L., Jr.........
New York, N. Y.
Armitage, H. B....New York, N. Y.
Armitage, J. B........W. Allis, Wis.
Armitage, R. F.........Chicago, Ill.
Armour, J. W.........Detroit, Mich.
Arms, J. H. R....New York, N. Y.
Arms, M. H........Springfield, Vt.
Armstrong, C. E....New York, N. Y.
Armstrong, C. W......Ithaca, N. Y.
Armstrong, E. J......Eddystone, Pa.
Armstrong, E. P.......Portland, Ore.
Armstrong, E. R. .Atlantic City, N. J.
Armstrong, G........Cleveland, Ohio
Armstrong, G. S....New York, N. Y.
Armstrong, J. G....New York, N. Y.
Armstrong, L. H......Lawton, Okla.
Armstrong, R. E..Los Angeles, Calif.
Armstrong, W. M......Buffalo, N. Y.
Arnerich, P. F................
Buenos Aires, Argentina, S. A.
Arnett, R. R..........Kokomo, Ind.
Arnold, A. A......New Haven, Conn.
Arnold, A. B...........Racine, Wis.
Arnold, B. J............Chicago, Ill.
Arnold, C. B........Brooklyn, N. Y.
Arnold, E. E......E. Pittsburgh, Pa.
Arnold, G., Jr.......Cleveland, Ohio
Arnold, H. M.........Laramie, Wyo.
Arnold, P. J.........Yonkers, N. Y.
Arnstein, K............Akron, Ohio
Arnstein, L. A......New York, N. Y.
Aronson, M...........Boston, Mass.
Arthur, R. W......Rochester, N. Y.
Arthur, T. S......Broadalbin, N. Y.
Artley, W. H.........Savannah, Ga.
Asch, A. B........New York, N. Y.
Aseltine, A. W....Toronto, Ont., Can.
Ashby, J. C.......Washington, D. C.
Ashcroft, A. G......Yonkers, N. Y.
Ashenden, E. W...Minneapolis, Minn.
Asher, L. J...........Detroit, Mich.
Ashkinazy, S. B.....Brooklyn, N. Y.
Ashley, E. E., Jr....New York, N. Y.
Ashley, F. M......New York, N. Y.
Ashley, H. C.......Waterbury, Conn.
Ashmun, L. H........Midland, Mich.
Ashton, Randolph...Swarthmore, Pa.
Ashton, Roger..........Chicago, Ill.
Ashworth, G. B...Schenectady, N. Y.
Ashworth, J. V........Nutley, N. J.
Asimow, M.............Chicago, Ill.
Askew, M. A.........Louisville, Ky.
Asmussen, J........Milwaukee, Wis.
Assaykeen, I. V......Harrison, N. J.
Aston, J............Pittsburgh, Pa.

Atherholt, G. M......Pittsburgh, Pa.
Atkins, D. F........New York, N. Y.
Atkins, H. B......New York, N. Y.
Atkins, L. G........Charlotte, N. C.
Atkinson, C..........Pensacola, Fla.
Atkinson, E. H.........Atlanta, Ga.
Atkinson, E. S............Erie, Pa.
Atkinson, H. S.......New York, N. Y.
Atkinson, K...........Boston, Mass.
Atkinson, K. B..............
Moylan-Rose Valley, Pa.
Atkinson, R. L.......Alexandria, Va.
Atkinson, R. P....Indianapolis, Ind.
Atkinson, T. A.....Bakersfield, Calif.
Atkinson, V. L......Elizabeth, N. J.
Atkinson, W.......Address Unknown
Atlas, R. A......Staten Island, N. Y.
Attendu, A. C...Montreal, Que., Can.
Atterburry, G. R........Radnor, Pa.
Atterbury, T. W....Rochester, N. Y.
Atwater, H. A......Kansas City, Mo.
Atwater, W. C....Marshalltown, Iowa
Atwood, W. S....Montreal, Que., Can.
Auel, C. B.......E. Pittsburgh, Pa.
Auer, G..........Harrison, N. J.
Auerswald, H. R.......Tulsa, Okla.
Aug, W. F......Staten Island, N. Y.
Aughenbaugh, E. E........York, Pa.
Augustine, A.........Pittsburgh, Pa.
Aulich, W. M.........Lwów, Poland
Ault, E. S..........Cleveland, Ohio
Aumann, E. W. F....Ft. Wayne, Ind.
Austin, C. C...........Chicago, Ill.
Austin, G. H..................
Buenos Aires, Argentina, S. A.
Austin, H. R.......New York, N. Y.
Austin, P. P., Jr. San Francisco, Calif.
Austin, R. S....Bound Brook, N. J.
Austin, W. H..........Boston, Mass.
Austin, W. M........Pittsburgh, Pa.
Austin, W. S........Baltimore, Md.
Auten, D. E...........Akron, Ohio
Autenrieth, G. C....New York, N. Y.
Auth, G. H..Woodhaven, L. I., N. Y.
Avalos-Vez, B......Los Mochis, Mex.
Avery, C. B..........Duquesne, Pa.
Avery, C. L..........Rockford, Ill.
Avery, G. R....Corpus Christi, Tex.
Avery, H. L.........Groton, N. Y.
Avery, Harold Terry..Syracuse, N. Y.
Avery, Harold Tolman.Oakland, Calif.
Avery, H. W..........Auburn, N. Y.
Avery, J. R......W. Hartford, Conn.
Avery, J. W.........Cleveland, Ohio
Avery, T. M......Glens Falls, N. Y.
Avery, W. K......New York, N. Y.
Avery, W. R......New York, N. Y.
Avey, H. T........Milwaukee, Wis.
Avignone, C. J....Rutherford, N. J.
Avis, S. W............Boston, Mass.
Avnsoe, T..........New York, N. Y.
Avram, M. H.......Istanbul, Turkey
Axon, A. E..........Brisbane, Aust.
Axt, W. J., Jr........Newark, N. J.
Ayars, W. S.......New York, N. Y.
Ayer, L. S..........Plainfield, N. J.
Ayer, W. T........Wilmington, Del.
Ayers, R. G............Tulsa, Okla.
Ayres, R. W......Schenectady, N. Y.

B

Babayeon, M. A....Ahmedabad, India
Babcock, L. R.....Stamford, Conn.
Babcock, W. S., Jr....Orange, N. J.
Babeor, J. A.........Clifton, N. J.
Bach, G. W..............Erie, Pa.
Bacha, C. P....New Brunswick, N. J.
Bacheller, A. W........Boise, Idaho
Bachman, B. B........Ardmore, Pa.
Bachman, J. L.....Philadelphia, Pa.
Bachman, W. A........Elkhart, Ind.
Bachmann, A. B.....Hartford, Conn.
Backer, G. H........Summit, N. J.
Backus, R. A.......New York, N. Y.
Bacon, B. S...........Nutley, N. J.
Bacon, C. B .....Middletown, Conn.
Bacon, D. L......New Haven, Conn.
Bacon, G. W........New York, N. Y.
Bacon, H. E.......Philadelphia, Pa.
Bacon, J. L.........San Diego, Calif.
Bacon, L. F..........Monsanto, Ill.
Bacon, M........Los Angeles, Calif.
Bacon, R. H...........Chicago, Ill.
Bacso, P. A..........Trenton, N. J.
Baden, C. A........Stamford, Conn.
Baden, M. W.........Winfield, Kan.
Badenhausen, J. P..Philadelphia, Pa.
Baecher, B. J..Elmhurst, L. I., N. Y.
Baender, F. G......Glendale, Calif.
Baer, C. A.........New York, N. Y.
Baer, R..........Downers Grove, Ill.
Baetz, H...........New York, N. Y.
Baggaley, W........Cleveland, Ohio
Baggott, S. P..........Racine, Wis.
Bagley, G. D....Niagara Falls, N. Y.
Bahnson, F. F..Winston-Salem, N. C.
Bailey, A..........Springfield, Mass.
Bailey, A. D...........Chicago, Ill.
Bailey, A. T., Jr. Niagara Falls, N. Y.
Bailey, B. L....Niagara Falls, N. Y.
Bailey, C. A.............Gary, Ind.
Bailey, Chas. Forrest....Ashland, Ky.
Bailey, Chas. Franklin.........
Newport News, Va.
Bailey, C. J.......Bridgeport, Conn.
Bailey, C. R......Phillipsburg, N. J.
Bailey, C. S........Potsdam, N. Y.
Bailey, D. F........Dearborn, Mich.
Bailey, D. R...Palisades Park, N. J.
Bailey, E. G........New York, N. Y.
Bailey, Eugene G..New York, N. Y.
Bailey, E. H..........Newark, N. J.
Bailey, F. E........Fitchburg, Mass.
Bailey, G. D.........Camas, Wash.
Bailey, H. H.....Chattanooga, Tenn.
Bailey, J............Hamburg, N. Y.
Bailey, J. F......W. Lafayette, Ind.
Bailey, K. S.........Waterloo, Iowa
Bailey, N. P.......Brunswick, N. J.
Bailey, R. R........San Pedro, Calif.
Bailey, T. B., Jr......Palestine, Tex.
Bailey, W. J.......Philadelphia, Pa.
Bailey, W. S......College Park, Md.
Baillie, R. R.......Philadelphia, Pa.
Baily, R. W........Philadelphia, Pa.
Baily, T. O.........E. Orange, N. J.
Bainton, A. H.....Providence, R. I.
Baird, D........San Francisco, Calif.
Baird, H. B..........Pittsburgh, Pa.
Baits, S. G............Detroit, Mich.
Bak, A. K....Copenhagen, Denmark
Baker, A. L........New York, N. Y.
Baker, B. M............Fulton, Mo.
Baker, C. H., Jr.........Muncie, Ind.
Baker, C. W........New York, N. Y.
Baker, D. B........New York, N. Y.
Baker, D. G.........Holyoke, Mass.
Baker, E. C.........Stillwater, Okla.
Baker, H. E.........Muskegon, Mich.
Baker, H. J........Indianapolis, Ind.
Baker, H. M......Charleston, W. Va.
Baker, J. B........Philadelphia, Pa.
Baker, J. R..........Baltimore, Md.
Baker, L. E.......Long Beach, Calif.
Baker, N. L...........St. Louis, Mo.
Baker, R. D.........Pasadena, Calif.
Baker, Robt. E.....Cleveland, Ohio.
Baker, Roy E.........Reading, Mass.
Baker, R. H...........Boston, Mass.
Baker, R. M....Lynbrook, L. I., N. Y.
Baker, W. C.........Cleveland, Ohio
Baker, W. K......Washington, D. C.
Bakesef, S.........Los Angeles, Calif.
Bakhmeteff, B. A....New York, N. Y.
Bakradze, J........New York, N. Y.
Balch, W...........New York, N. Y.
Balchen, B............Oslo, Norway
Balcom, J. A........Plainfield, N. J.
Balcome, S. E......Worcester, Mass.
Baldenhofer, W.....Springfield, Ohio
Baldock, F. C.........Detroit, Mich.
Baldwin, B. L.......Cincinnati, Ohio
Baldwin, F. K..........Beloit, Wis.
Baldwin, H. P.........Detroit, Mich.
Baldwin, O. H.......Salcombe, Eng.
Baldwin, P. De G....New York, N. Y.
Baldwin, R. S........Rochester, Pa.
Baliff, J.......Salt Lake City, Utah
Balkan, S. A..........Boston, Mass.
Balko, G. A...............
Shawinigan Falls, Que., Can.
Ball, H. F..........New York, N. Y.
Ball, H. J............Lowell, Mass.
Ball, J. F.........Los Angeles, Calif.
Ball, L. R........Whitinsville, Mass.
Ball, W. S........Toronto, Ont., Can.
Ballantine, J. H....New York, N. Y.
Ballard, L..........New York, N. Y.
Ballard, R. F..........Chester, Pa.
Ballenger, R. O.....Wilmington, Del.
Ballentine, J. M.......Chicago, Ill.
Ballentine, W. I........Chicago, Ill.
Baller, P. W. G..............
W. New Brighton, S. I., N. Y.
Ballin, A. E............Tulsa, Okla.
Ballman, H. C......Cincinnati, Ohio
Ballou, F. H....Vancouver, B. C., Can.
Ballou, F. H. Jr..............
Picture Butte, Alta., Can.
Ballou, J. McK...Los Angeles, Calif.
Balogh, S. I........New York, N. Y.
Balough, C............Canton, Ohio
Balthasar, F. L.......Brookline, Mass.
Baltzell, W. H...Ojibway, Ont., Can.
Baltzly, C. C.......Philadelphia, Pa.
Banash, J. I...........Chicago, Ill.
Bance, E. S.........Asbury Park, N. J.
Banck, H. J. E.......Springfield, Ill.
Bancker, J. W.......New York, N. Y.
Bancroft, C. F....New Canaan, Conn.
Bancroft, N...........Detroit, Mich.
Bancroft, W........Philadelphia, Pa.
Bandelier, G. E..Oklahoma City, Okla.
Banfield, F. E., Jr. Whitinsville, Mass.
Banghart, L. E...Battle Creek, Mich.
Bangser, W.........New York, N. Y.
Banks, J. T..................
Recife (Pernambuco), Brazil, S. A.
Banks, T. K............Media, Pa.
Bannerman, C. R., Jr. New York, N. Y.
Bannister, B..........Pittsburgh, Pa.
Banta, J. S..........Waukegan, Ill.
Banta, T. C.........E. Chicago, Ind.
Baratta, H. E......Somerville, Mass.
Barba, C. E.........Philadelphia, Pa.
Barbe, M..........New York, N. Y.
Barber, C. E........Norwich, Conn.
Barber, W. J..........Villanova, Pa.
Barbieri, C..........New York, N. Y.
Barbolini, G...Long Island City, N. Y.
Barbour, D. L.........Jeannette, Pa.
Barbour, R..........New York, N. Y.
Barclay, H. W...Pelham Manor, N. Y.
Bardes, J. H., Jr......Beacon, N. Y.
Bareis, F............Cleveland, Ohio
Barger, L. W.......Lancaster, N. Y.
Bariffi, H. F.......Bridgeport, Conn.
Bariteau, A. J..........Chicago, Ill.
Bark, E.............Philadelphia, Pa.
Barker, E. L.......New Haven, Conn.
Barker, G. E......Washington, D. C.
Barker, G. S........Norristown, Pa.
Barker, Harry......New York, N. Y.
Barker, Herbert ....
Buenos Aires, Argentina, S. A.
Barker, J. W........New York, N. Y.
Barker, R. D.......Cincinnati, Ohio
Barker, R. H...........Moylan, Pa.
Barker, T...........New York, N. Y
Barker, V. D..........Westfield, N. J.
Barkley, J. F....Washington, D. C.
Barkley, W. R.........Jackson, Miss.
Barks, G. T....Chicopee Falls, Mass.
Barkstrom, E. C....San Marino, Calif.
Barlow, C.........Indianapolis, Ind.
Barlow, E. H..........Elizabeth, N. J.
Barlow, T. S......Mt. Vernon, N. Y.
Barnaby, R. S........Pensacola, Fla.
Barnard, C. H.........Boston, Mass.
Barnard, J. A......Philadelphia, Pa.
Barnard, N. C.....New York, N. Y.
Barnard, N. H........Lincoln, Neb.
Barnard, W. G.......Hartford, Conn.
Barnard, W. N.........Ithaca, N. Y.
Barnes, A. F..........Houston, Tex.
Barnes, C. A..........Palmetto, Ga.
Barnes, E. L...........Buffalo, N. Y.
Barnes, F. A........Cleveland, Ohio
Barnes, F. F..........Bristol, Conn.
Barnes, H. B.......Philadelphia, Pa.
Barnes, H. C....New Britain, Conn.
Barnes, H. G.........Lancaster, Pa.
Barnes, H. H.....Los Angeles, Calif.
Barnes, H. H., Jr.....New York, N. Y.
Barnes, H. M.......San Diego, Calif.
Barnes, H. P.........Cleveland, Ohio
Barnes, J. M.......Philadelphia, Pa.
Barnes, M. C.......Kansas City, Mo.
Barnes, R. M........Iowa City, Iowa
Barnes, T. C.........Cleveland, Ohio
Barnes, T. W....University City, Mo.
Barnes, W. O........Worcester, Mass.
Barnett, G. M........Penacook, N. H.
Barnett, J. M........Oakland, Calif.
Barnett, S. A.........Brooklyn, N. Y.
Barnhart, C. D......New York, N. Y.
Barnhart, H. J..........Marion, Ohio
Barningham, C. S...Providence, R. I.
Barnsley, H. J.......New York, N. Y.
Barnum, G. S.....New Haven, Conn.
Barnum, S. H.....New Haven, Conn.
Barnum, T. P............Troy, N. Y.
Barr, C. D........Birmingham, Ala.
Barr, J. H., Sr.........Ithaca, N. Y.
Barr, S. D..........New York, N. Y.
Barrance, J. A.....Jersey City, N. J.
Barrett, A. E..........St. Louis, Mo.
Barrett, D. O...........Tulsa, Okla.
Barrett, E. L...........Buffalo, N. Y.
Barrett, J. C., Jr.....Coronado, Calif.
Barrett, J. M........Cleveland, Ohio
Barrett, S. K.......New York, N. Y.
Barrett, W. F......New York, N. Y.
Barrett, W. J.......New York, N. Y.
Barron, C. M........New York, N. Y.
Barron, D. B........Rahway, N. J.
Barron, E. W....Guantanamo, Cuba.
Barron, Jacob T.......Newark, N. J.
Barron, John T.....Philadelphia, Pa.
Barrow, C. J..........Albany, N. Y.
Barrow, J..........Columbiana, Ohio
Barrows, D. S......Rochester, N. Y.
Barrows, J..........E. Haven, Conn.
Barrows, W. I.........Dayton, Ohio
Barry, E. H.........Worcester, Mass.
Barry, J. M........Birmingham, Ala.
Barry, T. J..........Pittsburgh, Pa.
Barry, W. B......Los Angeles, Calif.
Barstow, F. L........New York, N. Y.
Barta, G. L., Jr.....Brooklyn, N. Y.
Bartels, C. P........Hamilton, Ohio
Bartels, H..........Cincinnati, Ohio
Bartelt, P..........New York, N. Y.
Barten, E. A......Philadelphia, Pa.
Barth, C. G........Philadelphia, Pa.
Barthel, O. E.........Detroit, Mich.
Bartholet, D. F.........Seattle, Wash.
Bartholomew, E.......Detroit, Mich.
Bartlett, H........Cambridge, Mass.
Bartlett, H. G., Jr..Philadelphia, Pa.
Bartolero, C..........Berkeley, Calif.
Barton, A...........Berkeley, Calif.
Barton, A. R...........Chicago, Ill.
Barton, H..........San Diego, Calif.
Barton, R. B......Schenectady, N. Y.
Bartram, P. R......Catlettsburg, Ky.
Bartsch, A. G.........Newark, N. J.
Baruch, M........Los Angeles, Calif.
Barzen, R. G.......Kansas City, Mo.
Basan, B. R..........Golmuri, India
Bascom, T. D.........Cleveland, Ohio
Bascome, G. L........Richmond, Va.
Bassett, B. E...............Alton, Ill.
Bassett, G. B..........Buffalo, N. Y.
Bassett, G. P., Jr....Jenkintown, Pa.
Bassett, R. M......Philadelphia, Pa.
Bassett, W. G. R....New York, N. Y.
Bassler, D. M.........Hoopeston, Ill.
Bassoff, A. B........New York, N. Y.
Bastian, H. S.........Portland, Ore.
Batchelder, N. A..Welland, Ont., Can.
Bateman, E. L...Johannesburg, Africa
Bateman, G. F.....New York, N. Y.
Bateman, T. P.........Detroit, Mich.
Bates, A. C.......Philadelphia, Pa.
Bates, A. H.........Cleveland, Ohio
Bates, C. J...........Hamilton, Ohio
Bates, D. M........Philadelphia, Pa.
Bates, E. N..........Portland, Ore.
Bates, G. H.........Cranford, N. J.
Bates, Harvey C.......Augusta, Kan.
Bates, Howard C..........Bath, Me.
Bates, H. H.........Ridley Park, Pa.
Bates, N. W.........Cohasset, Mass.
Bates, R. H...........Muncie, Ind.
Batesole, D. E......Stamford, Conn.
Batie, J. E...........Detroit, Mich.
Bato, A. A.........E. Orange, N. J.
Batt, W. L........Philadelphia, Pa.
Battey, P. L..........Chicago, Ill.
Battey, W. A.........Haverford, Pa.
Battin, W. L., Jr...W. New York, N. J.
Battle, J. R.......Philadelphia, Pa.
Battles, G. W...........Moline, Ill.
Baudry, P.......W. Homestead, Pa.
Baudry, R. A........Pittsburgh, Pa.
Bauer, A. A........Berkeley, Calif.
Bauer, C. A........Evansville, Ind.
Bauer, C. J., Jr......Saginaw, Mich.
Bauer, C. L........Springfield, Ohio
Bauer, E. C..........Newark, N. J.
Bauer, E. K....Thompsonville, Conn.
Bauer, F. S..........Boulder, Colo.
Bauer, G. C..................
Port Washington, L. I., N. Y.
Bauer, H. E.......S. Milwaukee, Wis.
Bauer, H. J........New York, N. Y.
Bauer, J. R.........Cincinnati, Ohio
Bauer, P. W......New Britain, Conn.
Baugh, W. S..........Wichita, Kan.
Baugher, E. J..........Akron, Ohio
Bauhan, A. E.........Newark, N. J.
Baum, R. F...........Detroit, Mich.
Bauman, E.........New York, N. Y.
Bauman, H. A..................
Forest Hills, L. I., N. Y.
Bauman, J. A........Brooklyn, N. Y.
Baumann, C. C.........Aurora, Ill.
Baumann, F. J...........Enka, N. C.
Baumann, G. W...............
Lynbrook, L. I., N. Y.
Baumann, H.........New York, N. Y.
Baumeister, P. A...New York, N. Y.
Baumeister, T., Jr..New York, N. Y.
Baumgartner, C. G....Ambridge, Pa.
Baur, W. E.........Dorchester, Mass.
Bausch, C. L.........Rochester, N. Y.
Bausch, E.*...........Buffalo, N. Y.
Bausch, F. E...........St. Louis, Mo.
Bauser, L. E.........Brooklyn, N. Y.
Baxley, C. H.......New York, N. Y.
Baxter, A. H..........Buffalo, N. Y.
Baxter, E. D...........Buffalo, N. Y.
Baxter, J. W......Ellwood City, Pa.
Baxter, M. L., Jr....Rochester, N. Y.
Bayer, L. F....San Francisco, Calif.
Bayliss, R. N.......Bloomfield, N. J.
Bayliss, W. A..........Boston, Mass.
Baylor, J. E............Canton, Ill.
Bayntun, R. S..................
Rio de Janeiro, Brazil, S. A.
Bayrer, L. G.......Plantsville, Conn.

* Non-Member.

Beach, C. S. . . . . Bennington, Vt.
Beachler, E. D. . . . Schenectady, N. Y.
Bealing, E. . . . . Avoncroft, Eng.
Beall, A. L. . . . . Paterson, N. J.
Beals, R. O. . . . . Chicago, Ill.
Beam, P. H. . . . . Cincinnati, Ohio
Beaman, P. A. . . . . . Worcester, Mass.
Bean, C. H. . . . . . Bound Brook, N. J.
Bean, H. S. . . . . Washington, D. C.
Bean, L. G. . . . . Waterbury, Conn.
Bean, P. H. . . . . . . Jersey City, N. J.
Bean, T. W. . . . . Oakland, Calif.
Beaney, W. E. . . . New London, Conn.
Beanfield, B. F. . . . Los Angeles, Calif.
Beanfield, R. McC. . Los Angeles, Calif.
Bearce, G. D. . . . . Bucksport, Me.
Beard, T. H. . . . . . . Bridgeport, Conn.
Beard, T. W. . . . . Louisville, Ky.
Beardsley, E. G. . . . . Olean, N. Y.
Beardsley, H. I. . . . New York, N. Y.
Beatie, C. E. . . . . . Los Angeles, Calif.
Beattie, F. C. . . . . Akron, Ohio
Beattie, J. A. . . . . . El Segundo, Calif.
Beatty, C. E. . . . . Denver, Colo.
Beauchemin, A. O. . . New York, N. Y.
Beaumont, J. C. . . . . . . Detroit, Mich.
Beausoleil, R. J. . Montreal, Que., Can.
Beaven, H. E. . . . . Boston, Mass.
Beavers, G. R. . Kitchener, Ont., Can.
Bech, J. . . . . Barcelona, Spain
Bechert, F. J. . . . . . . New York, N. Y.
Bechtel, A. L. . . . . Cleveland, Ohio
Bechtel, G. M. . . . . Allentown, Pa.
Bechtel, J. N. . . . . . Philadelphia, Pa.
Beck, C. E. . . . . Kansas City, Mo.
Beck, E. S. . . . . Boston, Mass.
Beck, G. C. . . . . Brooklyn, N. Y.
Beck, G. D. . . . . New Orleans, La.
Beck, H. V. . . . . Norman, Okla.
Beck, J. D. . . . . New Orleans, La.
Beck, L. J. . . . . New York, N. Y.
Beck, M. A. . . . . Milwaukee, Wis.
Beck, R. . . . . Bridgeport, Conn.
Beck, W. A. . . . . . Schenectady, N. Y.
Becker, B. C. . . . . N. Canton, Ohio
Becker, C. S. . . . . Anderson, Ind.
Becker, H. K. . . . . Chicago, Ill.
Becker, J. . . . . New York, N. Y.
Becker, P. M., Jr. . . . . . Chicago, Ill.
Becker, W. O. . . . . . . Brooklyn, N. Y.
Beckjord, W. C. . . . . . . Pittsburgh, Pa.
Beckman, L. J. . . . . Chicago, Ill.
Beckstrand, E. H. Salt Lake City, Utah
Beckwith, B. L. . . . .
Buenos Aires, Argentina, S. A.
Beckwith, E. L. . . . . Chicago, Ill.
Beckwith, O. P. . . . . . Yonkers, N. Y.
Beckwith, T. G. . . . . . Pittsburgh, Pa.
Beckwith, W. H. . . . . . Yonkers, N. Y.
Beckwith, W. S. . . . Chevy Chase, Md.
Bedinger, A. F. G. . . Knoxville, Tenn.
Beebe, C. R. . . . . . . Green River, Utah
Beebe, R. O. . . . . Newark, N. J.
Beecher, C. Y., Jr. . . . . . . Miami, Fla.
Beede, A. H. . . . . . . Bridgeport, Conn.
Beede, E. B. . . . . . . Providence, R. I.
Beedle, A. K. . . . . Detroit, Mich.
Beekley, W. C. . . . . . Hartford, Conn.
Beekman, H. M. . . Bedminster, N. J.
Beensen, C. . . . . Fort Lauderdale, Fla.
Beers, G. H. . . . . Alcoa, Tenn.
Beers, J. L. . . . . Brooklyn, N. Y.
Beers, O. E. . . . . Elkhart, Ind.
Beers, R. E. . . . . Boston, Mass.
Beers, R. L. . . . . Detroit, Mich.
Beeson, F. M. . . . . . Los Angeles, Calif.
Beeson, F. N., Jr. . . . . . Oak Park, Ill.
Beeson, K. H. . . . Beverly Hills, Calif.
Begeman, M. L. . . . . Austin, Tex.
Beggs, P. B. . . . San Francisco, Calif.
Beggs, W. E. . . . . Seattle, Wash.
Begley, R. W. . . . . . New York, N. Y.
Behar, M. F. . . . . Pittsburgh, Pa.
Behle, E. H. . . . . St. Louis, Mo.
Behr, F. J. . . . . San Juan, P. R.
Behrend, E. R. . . . . Erie, Pa.
Behrens, H. F. . . . . Chicago, Ill.
Behringer, C. D. . . . . . Brooklyn, N. Y.
Behrman, H. . . . . Brooklyn, N. Y.
Beirne, J. J. . . . . Reading, Pa.
Beitler, S. R. . . . . Columbus, Ohio
Bejarano, J. G. . . . . . Pittsburg, Calif.
Belcher, H. C. . . . . Proctor, Vt.
Belcher, W. J. . . . W. Hartford, Conn.
Beliaeff, S. B. . . . . Brooklyn, N. Y.
Beline, M. B. . . . New Rochelle, N. Y.
Beline, W. E. . . . . York, Pa.
Bell, A. F. . . . . New York, N. Y.
Bell, A. L. . . . . New York, N. Y.
Bell, A. O. . . . . Leominster, Mass.
Bell, C. W. . . . . Hazleton, Pa.
Bell, F. B. . . . . Pittsburgh, Pa.
Bell, F. J. . . . . . . Toronto, Ont., Can.
Bell, F. S. . . . . Toledo, Ohio
Bell, H. S. . . . . New York, N. Y.
Bell, J. S. . . . . Narberth, Pa.
Bell, J. W. . . . . Hampton, Va.
Bell, T. E. . . . . Atlanta, Ga.
Bell, W. R. . . . . Boston, Mass.
Bellamy, L. . . . . Cambridge, Mass.
Bellanca, G. M. . . . . Wilmington, Del.
Bellegia, F. . . . . . Niagara Falls, N. Y.
Bellinger, L. D. . . . Newport News, Va.
Belmont, R. I. . . . . . Worcester, Mass.
Beltz, G. W. . . . . Wadsworth, Ohio
Bemis, W. S. . . . . Chicago, Ill.
Bemm, H. F. . . . . Milwaukee, Wis.
Benda, H. R. . . . Cliffside Park, N. J.
Bendelius, A. . Middlesex Borough, N. J.
Bender, C. A., Jr. . . . New Orleans, La.
Bender, E. W., Jr. . . Philadelphia, Pa.
Bender, R. J. . . . . Chicago, Ill.
Bendick, M. . . . . Elizabeth, N. J.
Benedetti, G. G. . . . New York, N. Y.
Benedict, C. H. . . . . . Bethlehem, Pa.
Benedict, L. C. . . . . . New Orleans, La.
Benedict, L. L. . Grand Rapids, Mich.
Benedict, O., Jr. . . . . . Brooklyn, N. Y.
Benedict, W. E. . . . . Trenton, N. J.
Benedict, W. L. . . . Cochituate, Mass.
Benes, G. P. . . . . Cleveland, Ohio
Benesh, J. A. . . Pompton Lakes, N. J.
Benét, L. V. . . . . . . Washington, D. C.
Benfer, M. F. . . . . Brooklyn, N. Y.
Benjamin, C. H. . Washington, D. C.
Benjamin, M. W. . . . . . Detroit, Mich.
Benjamin, R. N. . . . . Atlanta, Ga.
Benjes, E. M. . . . . Baltimore, Md.
Benner, P. B. . . . . Peoria, Ill.
Bennett, A. F. . . . . . . Providence, R. I.
Bennett, B. F. . . . Martins Ferry, Ohio
Bennett, C. G. . . . . . . Thomaston, Conn.
Bennett, Chas. Wilbur. . Pittsburgh, Pa.
Bennett, Clinton Wendell. . . . . . .
Boston, Mass.
Bennett, D. A. . . . . . New York, N. Y.
Bennett, F. S. . . . Schenectady, N. Y.
Bennett, G. L. . St. George, S. I., N. Y.
Bennett, G. W. . . . . . New York, N. Y.
Bennett, H. A. . . . . Toledo, Ohio
Bennett, Harry G., Jr. . . . .
Richmond Hill, L. I., N. Y.
Bennett, Henry Geo. . New York, N. Y.
Bennett, H. M. . . . New Haven Conn.
Bennett, J. G. . . . . . Philadelphia, Pa.
Bennett, J. S., 3rd. . Philadelphia, Pa.
Bennett, L. W. . . . . . New York, N. Y.
Bennett, M. C. . . . . Lewiston, Me.
Bennett, T. A. . . . . . . New York, N. Y.
Bennett, W. H. . . . . . Johnstown, Pa.
Bennett, W. H. K. . . . . . Chicago, Ill.
Benning, V. L. . . . Cape Town, Africa
Benns, C. P. . . . . Cranston, R. I.
Benoit, A. W. . . . . Boston, Mass.
Benoit, L. W. . . . . Reading, Pa.
Benscoter, D. B. . . . Knoxville, Tenn.
Bensinger, M. . . . . . Washington, D. C.
Bensinger, S. . . . . Chicago, Ill.
Benson, A. E. . . Indian Orchard, Mass.
Benson, C. F. . . . . Chicago, Ill.
Benson, C. N. . . . . . . Philadelphia, Pa.
Benson, D. C. . . . . Owensboro, Ky.
Benson, H. F. . . . . Whitman, Mass.
Benson, J. G. . . . . . . Cambridge, Mass.
Bent, W. G. . . . . Wealdstone, Eng.
Bentley, G. L. . . . . . . Birmingham, Ala.
Bentley, H. . . . . Calcutta, India
Bentley, O. D. H. . . . . . Boston, Mass.
Bently, J. G. . . . . Chicago, Ill.
Benton, H. W. . . . . Denver, Colo.
Benzien, F. . . . . Bayonne, N. J.
Benzon, G. H., Jr. . . Philadelphia, Pa.
Beran, C. F. . . . . New York, N. Y.
Berard, S. J. . . . . Providence, R. I.
Bercaw, C. A. . . . . . . Philadelphia, Pa.
Beretta, J. W. . . . . . San Antonio, Tex.
Berg, G. P. . . . . Hopewell, Va.
Berg, H. H. . . . . Newark, N. J.
Berg, H. J. . . . . . San Francisco, Calif.
Berg, H. O. . . . . Paris, France
Bergan, M. P. . . . . . . Plainville, Conn.
Bergen, H. B. . . . . Cincinnati, Ohio
Berger, E. B. . . . . . Hackensack, N. J.
Berger, F. A. . . . . St. Louis, Mo.
Berger, G. G. . . . . New York, N. Y.
Berger, J. G. . . . . Newark, N. J.
Berger, J. W. . . . . Beacon, N. Y.
Berger, K. . . . . Seattle, Wash.
Bergey, J. E. . . . . . . Philadelphia, Pa.
Berggren, K. G. . . . . W. Orange, N. J.
Bergh, R. C. . . Woodmere, L. I., N. Y.
Bergh, W. H. . . . . Wayland, Iowa
Bergland, W. S. . . . . Wilmington, Del.
Bergman, C. A. . . . . Bagaha, India
Bergman, D. J. . . . . Chicago, Ill.
Bergmann, A. A. . . . . Chicago, Ill.
Bergmann, C. . . . . Newark, N. J.
Bergmann, C. R. . . . . . E. Orange, N. J.
Bergner, H. W. . . . . E. Chicago, Ind.
Bergquam, N. K. . . . . . Portland, Ore.
Bergquist, J. G. . . . . . New York, N. Y.
Bergseth, R. A. . . . . . New York, N. Y.
Berkley, H. W. . . . Boulder City, Nev.
Berkley, W. E. . . . . Dallas, Tex.
Berley, E. F. . . . . Rutherford, N. J.
Berley, M. E. . . . . . . Rutherford, N. J.
Bernard, H. B. . . . . Tulsa, Okla.
Bernhard, R. . . . . Allentown, Pa.
Bernhard, R. L. . . . . Easton, Pa.
Berninger, R. D. . . . . Pittston, Pa.
Bernitt, E. W. . . . . Detroit, Mich.
Bernner, M. St. J. . . . New York, N. Y.
Bernstein, E. J., Jr. . New York, N. Y.
Berolzheimer, H. . . . . New York, N. Y.
Berresford, A. W. . . New York, N. Y.
Berrian, K. J. . . . . . Jersey City, N. J.
Berry, C. H. . . . . Cambridge, Mass.
Berry, D. W. . Garden City, L. I., N. Y.
Berry, E. L. . . . . Chicago, Ill.
Berry, F. E. . . . . Boston, Mass.
Berry, F. R. . . . . New York, N. Y.
Berry, J. F., Jr. . San Francisco, Calif.
Berry, R. E. . . . . Berkeley, Calif.
Berryman, H. O. . . . . . Baltimore, Md.
Bertelsen, C. . . . . Brooklyn, N. Y.
Bertram, H. G. . . . . Dundas, Ont., Can.
Bertsch, J. C. . . . . Buffalo, N. Y.
Beshers, H. M. . . . . . . Aruba, D. W. I.
Bessemer, M. E. . . . . Philadelphia, Pa.
Bessio, O. . . . . New York, N. Y.
Best, J. L. . . . . St. Louis, Mo.
Best, R. D. . . . . Ponca City, Okla.
Bester, L. R. . . . . Staten Island, N. Y.
Beth, H. W. H. . . . . . Worcester, Mass.
Beth, W. F. . . . . Worcester, Mass.
Bethon, H. E. . . . . . Washington, D. C.
Betterley, E. W. . . . Springfield, Mass.
Bettis, A. E. . . . . Kansas City, Mo.
Bettman, R. . . . . New York, N. Y.
Betts, P. . . . . Belmar, N. J.
Betts, W. L. . . . . New York, N. Y.
Betts, W. W. . . . . Rockford, Ill.
Betty, B. B. . . . . Urbana, Ill.
Betz, L. D. . . . . Philadelphia, Pa.
Betzler, H. W. . . . . . . New York, N. Y.
Beukema, L. V. . . . . Detroit, Mich.
Beutel, A. P. . . . . Midland, Mich.
Beutler, A. J. . . . . Ampere, N. J.
Bevin, S. . . . . Toledo, Ohio
Beyer, B. W., Jr. . . . . . . Detroit, Mich.
Bhappu, K. K. . . . . Karachi, India
Bhatnagar, J. N. . . . Moghalpura, India
Bialog, E. S. . . . . Brooklyn, N. Y.
Bickel, C. A. . . . . Sidney, Ohio
Bickel, H. H. . . . . Saginaw, Mich.
Bicknell, C. E. . . . . . Wilmington, Del.
Biddison, P. McD. . . . . Dallas, Tex.
Bidstrup, H. A. . . . . . New York, N. Y.
Bidwell, E. M. . . . . Chicago, Ill.
Bidwell, P. W. . . . . Holyoke, Mass.
Biedess, A. R. . . . . Chicago, Ill.
Bielek, A. E. . . . . New York, N. Y.
Bier, P. . . . . Denver, Colo.
Bierbaum, C. H. . . . . Buffalo, N. Y.
Bieser, C. W. . . . . . . Cincinnati, Ohio
Bigelow, C. H. . . . . Plainfield, N. J.
Bigelow, C. M. . . . . Bound Brook, N. J.
Bigelow, F. B. . . . . Detroit, Mich.
Bigelow, G. E. . . . .
Huntington Park, Calif.
Bigge, J. . . . . New York, N. Y.
Bigger, T. W. . . . Schenectady, N. Y.
Biggert, F. C., Jr. . . . Pittsburgh, Pa.
Biggs, G. A. . . . . Springfield, Ohio
Biggs, W. F. . . . . Peoria, Ill.
Bilhuber, P. H. Long Island City, N. Y.
Billeter, J. . . . . . Salt Lake City, Utah
Billeter, R. . . . . . San Francisco, Calif.
Billey, P. R. . . . . New York, N. Y.
Billhardt, F. A. . . . . . . Cleveland, Ohio
Billich, W. H. . . . . Reading, Pa.
Billig, P. J. . . . . Brooklyn, N. Y.
Billings, A. W. K. . . . .
São Paulo, Brazil, S. A.
Billings, D. G. . . . Toronto, Ont., Can.
Billings, E. J. . . . . . . New York, N. Y.
Billings, E. R. . . . . Newark, N. J.
Billings, F. C. . . . . Hartford, Conn.
Billings, J. H. . . . . . . Philadelphia, Pa.
Billipp, E. H. . . . . . . Newburgh, N. Y.
Billitch, H. . . . . New York, N. Y.
Billmyer, C. D. . . . . Kingston, R. I.
Billow, C. O. . . . . Wilmette, Ill.
Bilty, C. H. . . . . Milwaukee, Wis.
Binder, A. R. . . . . Passaic, N. J.
Binder, R. C. . . . . . W. Lafayette, Ind.
Bingaman, C. A. . . . . Reading, Pa.
Bingham, S. A., Jr. Spartanburg, S. C.
Binns, G. W. . . . . . . Cincinnati, Ohio
Binsse, H. B. . . . . . Washington, D. C.
Birchler, C. F. . . . . . . Cleveland, Ohio
Bird, J. C. . . . . . . Battle Creek, Mich.
Bird, L. G. . . . . Chicago, Ill.
Bird, M. . . . . San Francisco, Calif.
Bird, R. C. . . . . St. Louis, Mo.
Bird, S. P. . . . . E. Orange, N. J.
Birdsall, F. . . . . San Francisco, Calif.
Birdseye, C. . . . . Gloucester, Mass.
Birdsong, J. M. . . . . . Ft. Wayne, Ind.
Birk, P. M. . . . . Buffalo, N. Y.
Birkenlund, A. E. . . . . Brooklyn, N. Y.
Birkicht, E. R. . . . . . . Rochester, N. Y.
Birkland, S. . . . . San Francisco, Calif.
Birkukoff, R. R. . . . . . Brooklyn, N. Y.
Birmann, R. . . . . Trenton, N. J.
Bischof, G. J. . . . . Brooklyn, N. Y.
Bischoff, R. . . . . York, Pa.
Bishop, G. C. Garden City, L. I., N. Y.
Bishop, J. O. . . . . Denver, Colo.
Bissell, G. W. . . . . . . Monrovia, Calif.
Bisser, A. S. . . . . Dundalk, Md.
Bissinger, J. A., Jr. . . Pittsburgh, Pa.
Bittner, C. E. . . . . Brooklyn, N. Y.
Biwer, A. F. . . . . Elma, Iowa
Bixby, W. . . . . Boston, Mass.
Bjerre, F. . . . . Detroit, Mich.
Bjong L. . . . . Brooklyn, N. Y.
Bjorklund, E. E. . . . Cambridge, Minn.
Bjorndal, M. . . . . Newark, N. J.
Bjornsson, C. A. . . . . Olean, N. Y.
Bjurling, E. R. . . . . Boston, Mass.
Black, A. . . . . New York, N. Y.
Black, A. R. . . . . New York, N. Y.
Black, D. R. . Forest Hills, L. I., N. Y.
Black, E. N., 3rd. . . . . Haverford, Pa.
Black, H. M. . . . . Chicago, Ill.
Black, R. J. . . . . Detroit, Mich.
Black, S. B. . . . . W. Lynn, Mass.
Black, W. S. . . . . Baltimore, Md.
Blackall, F. S., Jr. . Woonsocket, R. I.
Blackburn, A. H. . . . . Worcester, Mass.
Blackburn, A. T. . . . Cincinnati, Ohio
Blackburn, C. H. . . . . New York, N. Y.
Blackman, A. O. . . . . New York, N. Y.
Blackman, R. C. . . . . . Blacksburg, Va.
Blackman, V. C. . . New Albany, Ind.
Blackshaw, J. . . . . . . New York, N. Y.
Blackstone, F. B. . . . Port Sulphur, La.
Blackwelder, C. D. . . Greenville, S. C.
Blackwell, H. C. . . . . Cincinnati, Ohio
Blades, R. T. . . . . . . Bartlesville, Okla.
Blair, A. H. . . . . Birmingham, Ala.
Blair, E. L. . . . . Boston, Mass.
Blair, J. A. . . . . Camden, N. J.
Blair, J. G. . . . . Yonkers, N. Y.
Blair, R. M. . . . . Corsicana, Tex.
Blair, T. H. . . . . Brooklyn, N. Y.
Blaisdell, A. H. . . . . . . Pittsburgh, Pa.
Blaisdell, B. H. . . . . Manila, P. I.
Blake, A. D. . . . .
W. New Brighton, S. I., N. Y.
Blake, A. H. . . . . Wollaston, Mass.
Blake, E. E. . . . . Biddeford, Me.
Blake, F. E. . . . . Albany, N. Y.
Blake, J. H., Jr. . . . . New York, N. Y.
Blake, J. W. . . . Oklahoma City, Okla.
Blake, T. W. . . . . Green Bay, Wis.
Blake, W. G. . . . Woodside, L. I., N. Y.
Blakeley, G. H. . . . . . . Bethlehem, Pa.
Blakeman, W. W. . . Cambridge, Mass.
Blakeslee, D. W. . . . . . Pittsburgh, Pa.
Blakeslee, H. R. . . . . Torrington, Conn.
Blakeslee, W. A. . . . Philadelphia, Pa.
Blanchard, A. G. . . . . . Shreveport, La.
Blanchard, E. P. . . . Bridgeport, Conn.
Blanchard, P. D. . . . . Chicago, Ill.
Blanchard, R. K. . . . . New York, N. Y.
Blanckenburg, E. . San Francisco, Calif.
Blandford, J. B., Jr. . Knoxville, Tenn.
Blanding, R. L. . . . Providence, R. I.
Blank, W. E. . . . . Dayton, Ohio
Blanksteen, S. C. . . . . New York, N. Y.
Blatchley, C. A. . . . Philadelphia, Pa.
Blaum, R. . . . . Bremen, Germany
Blaw, A. . . . . Canton, Ohio
Blee, H. H. . . . . Washington, D. C.
Blenko, W. J. . . . . Pittsburgh, Pa.
Blessing, W. H. . . . . Chicago, Ill.
Bletso, B. A. . . . . . . Youngstown, Ohio
Bletzacker, H. T. Salt Lake City, Utah
Blickman, J. A. . . . .
Amsterdam, Netherlands
Blirer, A. E. . . . . Edgewater, N. J.
Bliss, C. P. . . . . New York, N. Y.
Bliss, D. L., Jr. . San Francisco, Calif.
Bliss, H. D. . . . . New York, N. Y.
Bliss, P. E. . . . . Cleveland, Ohio
Bliss, W. C. . . . . St. Louis, Mo.
Bliss, W. D. . . . . Milwaukee, Wis.
Bliss, Z. R. . . . . Providence, R. I.
Blitz, E. . . . . New York, N. Y.
Bliven, P. . . . . Seattle, Wash.
Blixt, G. F. . . . . Glen Rock, N. J.
Blizard, J. . . . . New York, N. Y.
Blizard, J. R. Garden City, L. I., N. Y.
Bloch-Hiller, W. . . . New York, N. Y.
Block, E. L. . . . . New York, N. Y.
Block, L. F. . . . . Newark, N. J.
Blocker, H. A., Jr. . . . Milwaukee, Wis.
Blodgett, D. E. . . . . Norman, Okla.
Blohm, A. H. . . . . Chicago, Ill.
Blom, C. . . . . Portland, Ore.
Blomquist, C. A. G., Jr. . . . .
Chicago, Ill.
Blood, H. L. . . . . Worcester, Mass.
Bloom, J. R. . . . . . Washington, D. C.
Bloom, K. E. . . . . Oakland, Calif.

Bloom, K. W..........Berwick, Pa.
Bloomberg, D. J.....W. Lynn, Mass.
Bloomsburg, M. S..Charleston, W. Va.
Blose, J. F........Washington, D. C.
Bloss, L. C. M......Providence, R. I.
Blossom, F........New York, N. Y.
Blount, G. E.....W. Hartford, Conn.
Blount, W. L......Collinsville, Conn.
Blue, A. C..St. Catherines, Ont., Can.
Blum, J. K........New York, N. Y.
Blum, S...........Philadelphia, Pa.
Blum, W. W............Altoona, Pa.
Blumberg, F. E..San Francisco, Calif.
Blumberg, L.......Wilmington, Del.
Blumers, F.......Minneapolis, Minn.
Blundell, E. E.......Cleveland, Ohio
Blunt, J. G......Schenectady, N. Y.
Blunt, R. R......Schenectady, N. Y.
Boa, R. G. C..........Chicago, Ill.
Boak, T. I. S......New Haven, Conn.
Boardman, C. C........Monroe, La.
Boas, R. H............Reading, Pa.
Bobrovnichy, B. E...Lakewood, N. J.
Boccasile, G. I......Springfield, Mass.
Bocchio, R. R......N. Haledon, N. J.
Bock, K. G. W......New York, N. Y.
Bock, L. S..........Brooklyn, N. Y.
Bockius, C. A......Philadelphia, Pa.
Bockstahler, L. A., Jr.La Grange, Ill.
Bodie, B. V..........Baltimore, Md.
Bodinson, L. W........Aurora, Ill.
Bodmer, R. C.......Cleveland, Ohio
Bodor, A...........Newark, N. J.
Bodwell, H. L......Vandergrift, Pa.
Boehck, R. E.......Milwaukee, Wis.
Boehm, W. H......New York, N. Y.
Boehringer, H......New York, N. Y.
Boeke, T...........Reedsport, Ore.
Boekelman, H. L........Dallas, Tex.
Boelter, L..........Berkeley, Calif.
Boenig, R. W........Brooklyn, N. Y.
Boening, F. S......Milwaukee, Wis.
Boer, W..............Groton, Conn.
Boerngen, C. H......N. Canton, Ohio
Boesch, J. C., Jr....Thomaston, Ga.
Boetcher, H. N......Baltimore, Md.
Boettger, R..........Yonkers, N. Y.
Bogaerts, J. J....E. Pittsburgh, Pa.
Boger, C. E........N. Canton, Ohio
Boggiano, J. E.......Brooklyn, N. Y.
Boggs, R. W.......New York, N. Y.
Bohannon, G. W......Proctor, Minn.
Bohn, A. R..........Saginaw, Mich.
Bohn, G. C..........St. Paul, Minn.
Bohn, G. H..........Buffalo, N. Y.
Bohn, L. G.............Passaic, N. J.
Bohn, R. G......Battle Creek, Mich.
Bohnstengel, W........Topeka, Kan.
Boies, H. B............Chicago, Ill.
Boisvert, J. B..Plessisville, Que., Can.
Bolgiano, C. P......Baltimore, Md.
Bolgiano, G. F......Baltimore, Md.
Bolin, M. E........New York, N. Y.
Bollenback, A. W...Charlotte, N. C.
Bollinger, G. W....Brooklyn, N. Y.
Boltizar, A. L......Brooklyn, N. Y.
Bolton, C. H., Jr......Tampa, Fla.
Bolton, R. P.......New York, N. Y.
Boltwood, H......Washington, D. C.
Bonanno, J. L.......Irvington, N. J.
Bond, F. M.........Baltimore, Md.
Bond, H. A...........Albany, N. Y.
Bond, H. H., Jr..................
Springfield, L. I., N. Y.
Bond, P. C........New York, N. Y.
Bond, R. E.........New York, N. Y.
Bond, W. G........Wilmington, Del.
Bondy, W. S........Brooklyn, N. Y.
Bone, H. L...........Swissvale, Pa.
Bonham, C. F............Akron, Ohio
Bonham, H. J....Los Angeles, Calif.
Boniface, J. B........Newark, N. J.
Bonine, C. E.......Philadelphia, Pa.
Bonine, J. G............Chicago, Ill.
Bonner, H.........Philadelphia, Pa.
Bonner, J. C.....................
Jackson Heights, L. I., N. Y.
Bonnett, J. C......Greenwich, Conn.
Bonnett, L. B.......Elizabeth, N. J.
Bonsall, J........Clarksburg, W. Va.
Bonstow, T. L.........London, Eng.
Booker, H. N........Lancaster, Ohio
Booker, W. F., Jr....Louisville, Ky.
Booraem, J. F......Greenwich, Conn.
Boos, J. A........Mt. Vernon, N. Y.
Booth, C. A...........Buffalo, N. Y.
Booth, D. M.........Buffalo, N. Y.
Booth, H. W...........Oil City, Pa.
Borchardt, A. H...............
Upper Montclair, N. J.
Borda, N. B..........Mexico, Mex.
Borden, M. M......Philadelphia, Pa.
Borden, W. H...San Francisco, Calif.
Borg, E. H........Des Moines, Iowa
Borgstedt, H. N....New York, N. Y.
Borie, R...........Philadelphia, Pa.
Borland, John......New York, N. Y.
Borland, John.........Canton, Ohio
Bormann, H. R......Milwaukee, Wis.
Born, J. E...........Milwaukee, Wis.
Born, W. G............Chicago, Ill.
Borovoy, S.........Providence, R. I.
Borromeo, C. O..........Cebu, P. I.
Borton, G. W......Philadelphia, Pa.
Bosbyshell, J. H....Philadelphia, Pa.
Bose, K. K..............Simla, India
Bose, S. N........Jamshedpur, India
Bosler, L. C........Philadelphia, Pa.
Bosserman, C. A.....Glendale, Calif.
Bossert, C. P........Milwaukee, Wis.
Bossinger, E. L....Philadelphia, Pa.
Bostic, J. A.........Barberton, Ohio
Bostock, R. N........Newark, N. J.
Boston, O. W......Ann Arbor, Mich.
Boswell, W. L...........Maurer, N. J.
Bosworth, R. L.......Holyoke, Mass.
Bott, G. R..........Stamford, Conn.
Botta, A...........New York, N. Y.
Botteron, L. K.........Omaha, Neb.
Bottomley, H. F..Arkansas City, Kan.
Botwinick, B.......New York, N. Y.
Bouick, J. B....San Francisco, Calif.
Bourgard, F. D......Elmwood, Conn.
Bourgarde, L. F....Brooklyn, N. Y.
Bourke, E. E.....Washington, D. C.
Bourne, G. L......New York, N. Y.
Bousfield, A.......Hollidaysburg, Pa.
Bouton, G. I..........Detroit, Mich.
Bouvier, G. A....Minneapolis, Minn.
Bovard, P. F....San Francisco, Calif.
Bovee, J. L., Jr......Anaheim, Calif.
Bowdry, Wm. P., Jr....Dallas, Tex.
Bowen, E. W.........Hopewell, Va.
Bowen, F. M.......Ann Arbor, Mich.
Bowen, H. S.........Seattle, Wash.
Bowen, L..........Muscatine, Iowa
Bowen, P. P....N. Tonawanda, N. Y.
Bowen, W. S.......Westfield, N. J.
Bowen, W. V........Baltimore, Md.
Bower, E. I........Amesbury, Mass.
Bower, H. W........Carteret, N. J.
Bower, J. G........New York, N. Y.
Bower, R. G.........Detroit, Mich.
Bowerman, M. R......Alliance, Ohio
Bowers, J. A........Elizabeth, N. J.
Bowers, J. H..........Bogota, N. J.
Bowers, W. W........Walters, Okla.
Bowes, T. D., Jr.....Cleveland, Ohio
Bowie, R. S.......Mt. Vernon, Ohio
Bowlus, B. H.............York, Pa.
Bowman, C. J., Jr....Burbank, Calif.
Bowman, H. T.......Philadelphia, Pa.
Bowman, J. S......Knoxville, Tenn.
Bowman, R. G..Elmhurst, L. I., N. Y.
Bowman, R. A......Philadelphia, Pa.
Boyar, S. L.....Chicago Heights, Ill.
Boyce, F. G..........Jackson, Mich.
Boyce, G. P..................
Forest Hills, L. I., N. Y.
Boyd, J. E.........Columbus, Ohio
Boyd, J. T........New York, N. Y.
Boyd, L. R...........Newton, Iowa
Boyd, W. A.........New York, N. Y.
Boyd, Wm. Wallace..Cleveland, Ohio
Boyd, Wm. Wray........Tulsa, Okla.
Boye, B. L.........New York, N. Y.
Boyer, E. D.......Watertown, N. Y.
Boyer, E. S........New York, N. Y.
Boyer, F. G. L.......Hamilton, Ohio
Boyer, F. Q.......Asheville, N. C.
Boyer, J. R........Wilmington, Del.
Boyle, W. G.......Pittsburgh, Pa.
Boyles, R. M.........St. Louis, Mo.
Boylon, F. O...........Chester, Pa.
Boynton, A. J..........Chicago, Ill.
Boynton, A. L.Tocopilla, Chile, S. A.
Boynton, E. S.......E. Orange, N. J.
Boynton, J. E........Nashville, Tenn.
Boynton, W. D.......Baltimore, Md.
Boynton, W. S.........Detroit, Mich.
Brace, N. G.......Washington, D. C.
Bracht, J. P...........Akron, Ohio
Brackett, N., Jr....Philadelphia, Pa.
Brackin, R. F......Philadelphia, Pa.
Bradac, G..............Chicago, Ill.
Bradford, L. J.....State College, Pa.
Bradford, W.........Wilmington, Del.
Bradley, E. H.......Providence, R. I.
Bradley, E. P.........St. Louis, Mo.
Bradley, F. L......Ridgewood, N. J.
Bradley, H. L.......Milwaukee, Wis.
Bradley, J. A.......Terre Haute, Ind.
Bradley, J. C., Jr....Pittsburgh, Pa.
Bradley, J. H.........Detroit, Mich.
Bradley, L. F..........Atlanta, Ga.
Bradley, V. A.........Trenton, N. J.
Bradner, A. F......Middletown, N. Y.
Bradt, M..................Erie, Pa.
Brady, H. S......Clarksburg, W. Va.
Brady, J. J...........Boston, Mass.
Braemer, W. G. R...Philadelphia, Pa.
Bragdon, G. D......Philadelphia, Pa.
Bragg, D. K..........Foxboro, Mass.
Brailo, G. P........New York, N. Y.
Brainard, B. B......Manhattan, Kan.
Braine, B. G........New York, N. Y.
Braine, D. L........New York, N. Y.
Brakeman, R. E...Alabama City, Ala.
Branch, A. M..........St. Louis, Mo.
Brand, G. B........New York, N. Y.
Brand, H. H..........Hopewell, Va.
Brand, W. N............Ithaca, N. Y.
Brandenburg, S. A......Sidney, Ohio
Brandes, L. C.Grant City, S. I., N. Y.
Brandin, W. H......New York, N. Y.
Brands, J. W..........Maurer, N. J.
Brandt, C. A. W.....New York, N. Y.
Brandt, E. H., Jr....Charlotte, N. C.
Brandt, F.........Leipzig, Germany
Brandt, F. C..........St. Louis, Mo.
Brandt, H. B......Cincinnati, Ohio
Brasch, E. F........Lewiston, Idaho
Brasch, J.........Los Angeles, Calif.
Brasher, P.............Kent, Conn.
Braun, J. B...........St. Louis, Mo.
Braun, J. J........Cincinnati, Ohio
Braungart, G., Jr.......Atlanta, Ga.
Braunlich, M. W....Philadelphia, Pa.
Bravo, O. F.........Mayaguez, P. R.
Bray, C. W...........Haverford, Pa.
Bray, C. D.........New York, N. Y.
Bray, L. J...........Bethlehem, Pa.
Breaker, E. R......San Antonio, Tex.
Breakey, G. M......New York, N. Y.
Breaznell, J. G......New York, N. Y.
Brecht, D. C......Schenectady, N. Y.
Breckenridge, A. L.New Haven, Conn.
Breckenridge, C. E...New York, N. Y.
Breckenridge, L. P..N. Ferrisburg, Vt.
Breda, T. K...............York, Pa.
Breed, E. M.....San Francisco, Calif.
Breen, P. J........New York, N. Y.
Breer, C...............Detroit, Mich.
Bregler, W. A. C.San Francisco, Calif.
Breguet, L. C..........Paris, France
Brehm, W. W.......New York, N. Y.
Breiby, N. H..........Madison, Wis.
Breidenbach, P. H......Kenton, Ohio
Breidenstein, L. W...Crockett, Calif.
Breitenstein, A. F..New Haven, Conn.
Brendlinger, W. B...Philadelphia, Pa.
Breneman, L. A......St. Paul, Minn.
Brengel, F. J.........Hillside, N. J.
Brennan, J. E......Cincinnati, Ohio
Brennan, J. I.......Pittsburgh, Pa.
Brennan, M. G.........Denver, Colo.
Brennan, Wm. E......Detroit, Mich.
Brennan, Wm. Edw....Portland, Ore.
Brenner, K. W.......Philadelphia, Pa
Brenner, M. M.......New York, N. Y.
Brenner, W. H..........Atlanta, Ga.
Brentlinger, J. M...Wilmington, Del.
Brenzinger, J......Bridgeport, Conn.
Brescka, R. S..........Kearny, N. J.
Breslove, J..........Pittsburgh, Pa.
Brett, H. E......Los Angeles, Calif.
Bretzfelder, M..................
Long Island City, L. I., N. Y.
Breunich, P. E....Mt. Vernon, N. Y.
Brevetta, F. C.......Brooklyn, N. Y.
Brewer, A.........Bridgeport, Conn.
Brewer, A. F.......New York, N. Y.
Brewer, G. S..............Erie, Pa.
Brewer, J. O. C.........Ponce, P. R.
Brewster, C. F.....Twin Falls, Idaho
Brewster, E. W...N. Plymouth, Mass.
Brice, N. E..........Milburn, N. J.
Brickenden, W. T..Toronto, Ont., Can.
Bridge, T. E.......Wilmington, Del.
Bridges, D. A.........Muncie, Ind.
Bridges, L. W..........Boston, Mass.
Bridgman, R. R......Hamburg, N. Y.
Briell, T. Jr.,..................
Maracaibo, Venezuela, S. A.
Briggs, E. J., Jr...Williamsport, Pa.
Briggs, H..............Direct, Tex.
Briggs, K. L........New York, N. Y.
Briggs, L. E.........Wollaston, Mass.
Briggs, W. C., Jr..Washington, D. C.
Brigham, E. E..........Ware, Mass.
Brigham, E. F.......Brookline, Mass.
Brigman, B. M........Louisville, Ky.
Brill, E. M.........Torrington, Conn.
Brill, G. M......Poughkeepsie, N. Y.
Brill, P. B.....................
Mariner's Harbor, S. I., N. Y.
Brillhart, S. E........Baltimore, Md.
Brindel, H. F............Tulsa, Okla.
Brindle, G. R......Great Bend, Kan.
Bringhurst, G. K...Philadelphia, Pa.
Brinkman, C. F.....New York, N. Y.
Brinley, C. E.......Philadelphia, Pa.
Brinton, W. C.......New York, N. Y.
Briscoe, C. B.........St. Louis, Mo.
Briscoe, R.............Detroit, Mich.
Brisick, J. C.......Maplewood, N. J.
Bristol, B. B.........Foxboro, Mass.
Bristol, E. S.......Philadelphia, Pa.
Bristol, H. H.......Waterbury, Conn.
Bristol, R. W.......New York, N. Y.
Britt, W. H.......Tonawanda, N. Y.
Brittain, J. R.....Los Angeles, Calif.
Britten, C. R..........Orange, N. J.
Brizzolara, R. D........Chicago, Ill.
Brizzolara, R. T.....New York, N. Y.
Broas, R. F..........Caldwell, N. J.
Brobeck, W. M......Piedmont, Calif.
Broberg, O. R....Los Angeles, Calif.
Brobston, J........Philadelphia, Pa.
Brociner, V.........New York, N. Y.
Brock, C. A..........Detroit, Mich.
Brock, G. E...........Monaca, Pa.
Brock, R. C......Elizabethton, Tenn.
Brockel, W. E.......Hoboken, N. J.
Brocklebank, A. P...New York, N. Y.
Broden, E. H.........Pittsburgh, Pa.
Broder, C..........New York, N. Y.
Broderick, J. F......New York, N. Y.
Broderick, R. E.........Nashua, N. H.
Brodie, J. S........New Orleans, La.
Brodin, C. O., Jr...Cincinnati, Ohio
Broeker, F. G..Rancagua, Chile, S. A.
Brohl, H. T............Buffalo, N. Y.
Brombacher, M. H. C...........
Palm Beach, Fla.
Bromberg, J........New York, N. Y.
Bromley, C. H......New York, N. Y.
Brondum, P. V......Cranford, N. J.
Bronson, C. E..........Kewanee, Ill.
Bronson, J. S........Memphis, Tenn.
Brooke, C. J., Jr......Houston, Tex.
Brooke, G. A., Jr...Philadelphia, Pa.
Brooke, H. St. G...New Haven, Conn.
Brooke, M........Huntington, W. Va.
Brooke, W. E.....Minneapolis, Minn.
Brookman, H. E.....Vermillion, S. D.
Brookover, P. E......Windsor, Colo.
Brooks, A. A........Wellsville, N. Y.
Brooks, C. C...........Chicago, Ill.
Brooks, C. W..........Scranton, Pa.
Brooks, D. F........Memphis, Tenn.
Brooks, E. A...........Atlanta, Ga.
Brooks, F. A..........Davis, Calif.
Brooks, F. T.........New York, N. Y.
Brooks, F. W........Cleveland, Ohio
Brooks, G. I..........Denver, Colo.
Brooks, H. W.........Fremont, Ohio
Brooks, J. A........Montclair, N. J.
Brooks, J. G........New York, N. Y.
Brooks, L. S.......Kansas City, Kan.
Brooks, M..............Urbana, Ill.
Brooks, M. E.........Pittsburgh, Pa.
Brooks, S. A...........Chicago, Ill.
Brooks, W. T.....Schenectady, N. Y.
Broome, E. L.........E. Orange, N. J.
Brootzkoos, S. D........Toledo, Ohio
Bros, C. W.......Minneapolis, Minn.
Brosius, E. E........Pittsburgh, Pa.
Brossart, J. A., Jr.......Chicago, Ill.
Brossman, C.......Indianapolis, Ind.
Brotzman, I. C.....Birmingham, Ala.
Broughton, W. W...New York, N. Y.
Broussard, J...........Chicago, Ill.
Brousseau, E. W......Camden, N. J.
Browe, E. L........Cumberland, Md.
Brower, J...........Milwaukee, Wis.
Brower, J. D......Johnstown, N. Y.
Brown, A.............Warren, Ohio
Brown, A. G........Manchester, Eng.
Brown, A. I.........Columbus, Ohio
Brown, A. K.......Upper Darby, Pa.
Brown, A. L...........Boston, Mass.
Brown, A. M.......Philadelphia, Pa.
Brown, A. T..........Newark, N. J.
Brown, A. W.........St. Louis, Mo.
Brown, B. F......Los Angeles, Calif.
Brown, C. A........Cincinnati, Ohio
Brown, C. B.........New York, N. Y.
Brown, C. D.........Hopedale, Mass.
Brown, C. E........Kansas City, Mo.
Brown, C. G...........Canton, China
Brown, C. G., Jr...Williamsport, Pa.
Brown, C. H.....Breckenridge, Tex.
Brown, C. L.........Farmville, Va.
Brown, C. T..........Syracuse, N. Y.
Brown, C. W.....New London, Conn.
Brown, D.........Los Angeles, Calif.
Brown, D. Q.........New York, N. Y.
Brown, D. S........Cincinnati, Ohio
Brown, E. F...........Swanton, Ohio
Brown, F. A. J........Lancaster, Pa.
Brown, G. B.............Peoria, Ill.
Brown, G. C........E. Orange, N. J.
Brown, G. I.............Chicago, Ill.
Brown, G. L........New York, N. Y.
Brown, H. A...............Cyril, Okla.
Brown, Herbert H......Mancos, Colo.
Brown, Howard H...New York, N. Y.
Brown, H. J...........Boston, Mass.
Brown, H. M......Philadelphia, Pa.
Brown, Harry Wheeler..........
Battle Creek, Mich.
Brown, Harry Wolston..........
Framingham, Mass.
Brown, J. A..Smithtown, L. I., N. Y.
Brown, J. C.......Los Angeles, Calif.
Brown, J. H........New York, N. Y.

Brown, J. J.........New York, N. Y.
Brown, J. M........Beaver Falls, Pa.
Brown, J. P........Philadelphia, Pa.
Brown, J. R.........Cleveland, Ohio
Brown, L. F.....Mineola, L. I., N. Y.
Brown, L. W..........Boston, Mass.
Brown, M. C.......Mt. Vernon, N. Y.
Brown, N. M.....Lincoln Park, Mich.
Brown, P..........Brooklyn, N. Y.
Brown, P. L........Philadelphia, Pa.
Brown, R. B.......Rutherford, N. J.
Brown, R. F.......Cambridge, Mass.
Brown, R. G......George School, Pa.
Brown, R. P.......Philadelphia, Pa.
Brown, R. R........Mt. Hope, C. Z.
Brown, Robt. S....New Britain, Conn.
Brown, Roger S..............
Upper Montclair, N. J.
Brown, R. T........Fairport, N. Y.
Brown, T., Jr........W. Lynn, Mass.
Brown, T. C...........Ashland, Ky.
Brown, T. W. F...............
Newcastle-on-Tyne, Eng.
Brown, Warren A....Florence, N. J.
Brown, William A.......Miami, Fla.
Brown, W. C.....Ogdensburg, N. Y.
Brown, W. H., Jr.....Auburn, R. I.
Brown, W. J.......Rochester, N. Y.
Brown, W. M...Port Townsend, Wash.
Brown, W. N.........Closter, N. J.
Brown, W. S.......Providence, R. I.
Brownback, H. L....Norristown, Pa.
Browne, A. T......Philadelphia, Pa.
Browne, B.........New York, N. Y.
Browne, F. A...........Wayne, Pa.
Browne, J. T.....Johnson City, N. Y.
Browne, L. W......Kansas City, Mo.
Browne, W. H...........Peoria, Ill.
Browning, F. H......Seattle, Wash.
Browning, R. E..Salt Lake City, Utah
Brownlie, D...........London, Eng.
Brownscombe, P. J...Brooklyn, N. Y.
Brownstein, B.........Aliquippa, Pa.
Brubaker, W. S..San Francisco, Calif.
Bruce, A. K...........London, Eng.
Bruce, Albert W..San Francisco, Calif.
Bruce, Alfred W.....New York, N. Y.
Bruck, A. G.......Cincinnati, Ohio
Bruckmann, H........Vienna, Austria
Bruckner, A........New York, N. Y.
Bruckner, R. E.........Beloit, Wis.
Bruehl, L..........New York, N. Y.
Bruemmer, C. H..New Britain, Conn.
Bruening, W. H......Pine Bluff, Ark.
Bruggemeier, G. H.......Akron, Ohio
Brugger, R...........Elizabeth, N. J.
Brugler, M. W.........Canton, Ohio
Bruhl, P. C...........Detroit, Mich.
Bruhn, N............Brooklyn, N. Y.
Bruhnke, L. T.......Wauwatosa, Wis.
Brumble, W. C.Philipse Manor, N. Y.
Brune, C. E.........New York, N. Y.
Brunett, A. L.....Washington, D. C.
Bruning, J. M......New York, N. Y.
Bruns, J. L............Austin, Tex.
Brunschwig, M........Brooklyn, N. Y.
Brusca, J. L.........Rockledge, Pa.
Brush, C. B.....New Rochelle, N. Y.
Brush, G. W..........Lansing, Mich.
Bruzelius, E. M....Kansas City, Kan.
Bryan, A. S.....Johnson City, Tenn.
Bryan, J. L...........Trenton, N. J.
Bryan, M. K...........Boston, Mass.
Bryan, W. E..........St. Louis, Mo.
Bryans, H. B.......Philadelphia, Pa.
Bryans, W. R.................
Hastings-on-Hudson, N. Y.
Bryant, E. J.......Greenfield, Mass.
Bryant, J. M.......Indianapolis, Ind.
Bryant, L. W.......Connersville, Ind.
Bryant, O. N.......Philadelphia, Pa.
Bryant, P. J..........Newark, N. J.
Bryant, R. E.........Lockport, N. Y.
Bryant, W. W......Rochester, N. Y.
Bryce, J............Milwaukee, Wis.
Bryden, C. W.......New York, N. Y.
Bryson, T. A............Troy, N. Y.
Bubar, H. H.........New York, N. Y.
Buccola, C. H..Woodside, L. I., N. Y.
Buchanan, D. D......Massillon, Ohio
Buchanan, J. P.....W. Orange, N. J.
Buchanan, M. O....Indianapolis, Ind.
Buchanan, W. C..........Peoria, Ill.
Buchen, J. C......San Leandro, Calif.
Bucher, P...........Columbus, Ohio
Buchmann, K. E..............
Falconbridge, Ont., Can.
Buck, C. A..........Bethlehem, Pa.
Buck, C. P.............Topeka, Kan.
Buck, E. S.........Fort Wayne, Ind.
Buck, W. H.......Washington, D. C.
Buckingham, E....Cambridge, Mass.
Buckingham, J. E.........Chicago, Ill.
Buckland, B. O....Schenectady, N. Y.
Bucklein, F. P....Los Angeles, Calif.
Buckler, A....New Dorp, S. I., N. Y.

Buckley, A. G..Cuyahoga Falls, Ohio
Buckley, G. M...New Rochelle, N. Y.
Buckley, J. H.............Akron, Ohio
Buckwalter, T. V.......Canton, Ohio
Budding, N. T.........Bayonne, N. J.
Budwell, L...........Richmond, Va.
Buehner, W. F. A...New York, N. Y.
Buell, J. E........Birmingham, Ala.
Buenger, E. F..........Chicago, Ill.
Buensod, A. C......New York, N. Y.
Buenting, O. W.......Swissvale, Pa.
Buerger, C. B........Pittsburgh, Pa.
Buerk, B. C...........Buffalo, N. Y.
Buerkle, E. C.......San Diego, Calif.
Buffinton, A. L...........Lynn, Mass.
Buffone, J. J...........Clifton, N. J.
Bugge, S. B..........Tomahawk, Wis.
Buhrendorf, F. G...New York, N. Y.
Buirgy, R. R.......Ft. Collins, Colo.
Buker, H...........Providence, R. I.
Bullard, D. B......Bridgeport, Conn.
Bullard, E. C......Bridgeport, Conn.
Bullard, E. P......Bridgeport, Conn.
Bullard, J. E.........Cranston, R. I.
Bullen, C. K.........Okmulgee, Okla.
Bullinger, C. E....State College, Pa.
Bullock, E. R.......Pawtucket, R. I.
Bullock, H. L.......New York, N. Y.
Bullock J. B........Baltimore, Md.
Bumgardner, H. E.....Detroit, Mich.
Bump, B. N.........Syracuse, N. Y.
Bunge, R. W.......New York, N. Y.
Bunke, E. W. D...Schenectady, N. Y.
Bunker, W. L.......Montclair, N. J.
Bunnell, S. H.......New York, N. Y.
Bunting, A...........Lincoln, Neb.
Bunting, F. W.............Erie, Pa.
Bunting, J. W.......Cincinnati, Ohio
Bunzel, E...........Peekskill, N. Y.
Buonaccorsi, A. L.San Francisco, Calif.
Burack, W. D.......Livingston, N. J.
Burbank, E. W..........Dallas, Tex.
Burbank, W. E.......Baltimore, Md.
Burch, A. M...........Rockford, Ill.
Burch, K. C......Los Angeles, Calif.
Burchett, W. J.........Newark, N. J.
Burden, H. W.........Homer, N. Y.
Burdge, L. R......Kansas City, Kan.
Burdick, H..........Hartford, Conn.
Burdick, L. R.....Washington, D. C.
Burdick, T. A....Flushing, L. I., N. Y.
Burdsall, E.......Port Chester, N. Y.
Burg, J......Colorado Springs, Colo.
Burgan, A. L.........Hubbell, Mich.
Burger, G. E.........Kingston, N. Y.
Burgess, C. G.........Pittsburgh, Pa.
Burgess, D............Buffalo, N. Y.
Burgess, J. R....Toronto, Ont., Can.
Burgess, K. A.....Toronto, Ont., Can.
Burgess, R. M....Jamshedpur, India
Burgey, S. S.......Pedricktown, N. J.
Burgomaster, J. E....Elizabeth, N. J.
Burgoyne, C. L......Cincinnati, Ohio
Burhoe, L. N........Seymour, Conn.
Burhorn, E...........Hoboken, N. J.
Burke, A. G., Jr........Chicago, Ill.
Burke, E. R...........Denver, Colo.
Burke, H. E.........Montrose, Calif.
Burke, H. M.Wappingers Falls, N. Y.
Burke, J...................Erie, Pa.
Burke, J. J., Jr......New York, N. Y.
Burke, R. E.......Union City, N. J.
Burke, R. F........Phœnixville, Pa.
Burke, T. F.........New York, N. Y.
Burke, W. A....Jamaica, L. I., N. Y.
Burkes, L. C.......Manhattan, Kan.
Burkhardt, C..........Canton, Ohio
Burkhardt, E. R........Holyoke, Mass.
Burkholder, C. I.....Charlotte, N. C.
Burley, G. W........Matunga, India
Burley, H. H.........Brooklyn, N. Y.
Burling, H. S.........Newark, N. J.
Burlingame, C. R.....Pittsburgh, Pa.
Burlingame, J. H...Cincinnati, Ohio
Burlingame, W. S..Minneapolis, Minn.
Burmester, R. L......Syracuse, N. Y.
Burmistroff, J. G...Philadelphia, Pa.
Burnell, J. G.....Castlemaine, Aust.
Burner, G.........Carson City, Nev.
Burnet, E. E.........Lincoln, Calif.
Burnett, E. S.........Amarillo, Tex.
Burnett, J. W...........Omaha, Neb.
Burnette, A. R......New York, N. Y.
Burnham, C. H. M...............
San Francisco, Calif.
Burnham, Leland F...Pittsburgh, Pa.
Burns, Alan Elmer..New York, N. Y.
Burns, Alan Elwin...New York, N. Y.
Burns, Arthur E....New York, N. Y.
Burns, A. L.........New York, N. Y.
Burns, C. H. McL.Welland, Ont., Can.
Burns, E. F........New York, N. Y.
Burns, H. S........New Orleans, La.
Burns, R. C.......Phillipsburg, N. J.
Burns, R. W.....Poughkeepsie, N. Y.
Burns, W. J.Kew Gardens, L. I., N. Y.

Burnside, M. C.........Toledo, Ohio
Burpee, C..........Philadelphia, Pa.
Burpee, F. E.........Lewisburg, Pa.
Burr, A. H............Houston, Tex.
Burr, F. M........Wilmington, Del.
Burr, W. C............Augusta, Me.
Burrell, E. P........Cleveland, Ohio
Burress, L. F..............Gary, Ind.
Burrill, H. G.........Baltimore, Md.
Burris, W. D........Coffeyville, Kan.
Burritt, J. R..........Denver, Colo.
Burritt, L. D........Elizabeth, N. J.
Burroughs, E. E......Brooklyn, N. Y.
Burroughs, J. H., Jr.Glen Ridge, N. J.
Burrow, E. A............Brady, Tex.
Burrows, R. J....Battle Creek, Mich.
Burrows, W. R........Whiting, Ind.
Bursley, J. A......Ann Arbor, Mich.
Burstein, A.........New York, N. Y.
Burt, C. R.........Hartford, Conn.
Burt, H. A.........Brooklyn, N. Y.
Burtenshaw, C. D.Roselle Park, N. J.
Burton, C. L., Jr........Akron, Ohio
Burton, G. H., Jr....Ft. Monroe, Va.
Burton, R. C.......Philadelphia, Pa.
Burton, W. D.......Pasadena, Calif.
Burtt, N. W..........Buffalo, N. Y.
Burwell, R. T......New Orleans, La.
Busby, W..............Chicago, Ill.
Busch, F...College Point, L. I., N. Y.
Busck, P. G..........Allentown, Pa.
Bush, H. M.........Columbus, Ohio
Bush, H. W.........Drexel Hill, Pa.
Bush, R. T............Berwick, Pa.
Bush, V...........Cambridge, Mass.
Bushfield, F. T.....Maplewood, N. J.
Bushley, H. R......Rochester, N. Y.
Bushnell, D. S......New York, N. Y.
Bushnell, F. N......Brookline, Mass.
Bushnell, H. C......Brooklyn, N. Y.
Bushnell, L. P.....Naugatuck, Conn.
Busse, F. E..........St. Louis, Mo.
Bussey, G. L........Alhambra, Calif.
Bussey, J. K......Los Angeles, Calif.
Buswell, J. M.........Fresno, Calif.
Butcher, A..........Pittsburgh, Pa.
Butcher, I. A.........Lexington, Ky.
Butcher, J. H......San Diego, Calif.
Butera, C. N.......Brooklyn, N. Y.
Butler, Chas. A....Jersey City, N. J.
Butler, Clarence A., Jr........
Kansas City, Mo.
Butler, C. F..........Portland, Ore.
Butler, E....Three Rivers, Que., Can.
Butler, E. W. R.Winnipeg, Man., Can.
Butler, F. A............Dallas, Tex.
Butler, H. M..........Athol, Mass.
Butler, H. W......New York, N. Y.
Butler, J. C..........Clinton, N. C.
Butler, W. E........Lexington, Ky.
Butler, W. H.......New York, N. Y.
Butrovich, G. W...Fairbanks, Alaska
Butt, H...........New York, N. Y.
Butterfield, A. G........Beloit, Wis.
Butterfield, A. W..Central Falls, R. I.
Butterfield, M. A......Lowell, Mass.
Butterfield, T. E.....Bethlehem, Pa.
Butterworth, G. J.......Chester, Pa.
Buttolph, B. G......Providence, R. I.
Buttron, W. C.........Albany, N. Y.
Buvinger, G. A........Dayton, Ohio
Buxbaum, W......New Haven, Conn.
Buxton, P. H............Alton, Ill.
Buyers, A. S......Washington, D. C.
Bye, N. C.........Philadelphia, Pa.
Byer, H. E........New York, N. Y.
Byers, H. R..........Denver, Colo.
Byers, M. F.........Newcastle, Ind.
Byll, A. J..............Beloit, Wis.
Bynum, E. A., Jr..Aransas Pass, Tex.
Byrnes, C. P........Pittsburgh, Pa.
Byrom, J. L.........Cleveland, Ohio

C

Cabaniss, W. M...Chattanooga, Tenn.
Cable, F. W.........Memphis, Tenn.
Cadeau, H.....................
Notre-Dame-de-Gravenchon, France
Cadwallader, H., Jr..Philadelphia, Pa.
Cadwallader, L. W.Washington, D. C.
Cadwallader, S..Woodside, L. I., N. Y.
Cady, C. I.........New York, N. Y.
Cady, E. F...........Buffalo, N. Y.
Cady, G. H........Providence, R. I.
Cady, H. R........Weehawken, N. J.
Cadzow, M...........Newark, N. J.
Cagnoni, G. J..........Kenvil, N. J.
Cahill, C. A........Milwaukee, Wis.
Cahill, D. T.....Jamaica, L. I., N. Y.
Cahill, E. H........Philadelphia, Pa.
Cahill, J. E.........New York, N. Y.
Cain, B. S................Erie, Pa.
Cain, J. N..........Ashtabula, Ohio
Caine, W. P.......Birmingham, Ala.

Cala, C. F..........Rochester, N. Y.
Calamari, P. L......New York, N. Y.
Calder, A. W., Jr...Providence, R. I.
Caldwell, E.........Milwaukee, Wis.
Caldwell, J. A...........Vivian, La.
Caldwell, W. E......New York, N. Y.
Califro, E........Mare Island, Calif.
Calkin, E. D..........Portland, Ore.
Call, A. E............Richmond, Va.
Call, L. J.......Niagara Falls, N. Y.
Callahan, J. G.......Brooklyn, N. Y.
Callahan, V. T......New York, N. Y.
Callahan, W. J......Brooklyn, N. Y.
Callan, J...........Kingsport, Tenn.
Callaway, C. R.....New York, N. Y.
Calmus, F. A....San Francisco, Calif.
Calnan, E. J.....Thorold, Ont., Can.
Camden, A. T.......Brooklyn, N. Y.
Cameron, A. P........London, Eng.
Cameron, C. E., Jr.....Newark, N. J.
Cameron, E. H..San Francisco, Calif.
Cameron, G. C.......Oak Park, Ill.
Cameron, H. S.......Brooklyn, N. Y.
Cameron, J. A.......Hartford, Conn.
Cameron, N. C.Westmount, Que., Can.
Cammann, O., Jr......Weston, Mass.
Camp, E. V............Atlanta, Ga.
Camp, G. D...........Mexico, Mex.
Camp, L. F., Jr.....Rochester, N. Y.
Camp, V. R.............Akron, Ohio
Camp, Wm. E......Philadelphia, Pa.
Camp, Wilmer E...Sacramento, Calif.
Campbell, A. L.....Painesville, Ohio
Campbell, C. A.....Watertown, N. Y.
Campbell, C. B.....Philadelphia, Pa.
Campbell, C. G...Toronto, Ont., Can.
Campbell, D........New York, N. Y.
Campbell, D. S.....New York, N. Y.
Campbell, E. D........Berwick, Pa.
Campbell, E. G......Pittsburgh, Pa.
Campbell, G..............York, Pa.
Campbell, G. E...Chattanooga, Tenn.
Campbell, G. M.........Rugby, Eng.
Campbell, G. W.........Miami, Fla.
Campbell, H. F....Philadelphia, Pa.
Campbell, J., Jr.....Elizabeth, N. J.
Campbell, J. H.........Dallas, Tex.
Campbell, J. M....Minneapolis, Minn.
Campbell, J. R........Ashland, Mass.
Campbell, J. S., Jr...Endicott, N. Y.
Campbell, J. W....Howes Cave, N. Y.
Campbell, L.........Westfield, Mass.
Campbell, L. B.....Waterbury, Conn.
Campbell, M. J......Milwaukee, Wis.
Campbell, N. J................
W. New Brighton, S. I., N. Y.
Campbell, O. F.......E. Chicago, Ind.
Campbell, R. D.........Dallas, Tex.
Campbell, R. J................
St. Johns, Newfoundland
Campbell, T. D........Hardin, Mont.
Campbell, T. J...Merchantville, N. J.
Campbell, W. A...............
Wallaceburg, Ont., Can.
Campione, J. L.........Chicago, Ill.
Canan, W. D........Pittsburgh, Pa.
Canavan, W. F..........Decatur, Ill.
Canby, H. B...........Dayton, Ohio
Candee, A. H.......Rochester, N. Y.
Candee, F. W........Pullman, Wash.
Cannard, R. E......Manitowoc, Wis.
Cannon, J. P..........Linden, N. J.
Cantwell, J. D., Jr...Bettendorf, Iowa
Canuel, J. A...........Paris, France
Capo, J. J.........New York, N. Y.
Caponecchi, J. A. B...Coraopolis, Pa.
Capp, J. A.......Schenectady, N. Y.
Capp, W. C...........Venice, Calif.
Capron, J. D.........Lynchburg, Va.
Carbone, W. E........Newark, N. J.
Card, F. M........Bridgeport, Conn.
Cardullo, F. E.....Cincinnati, Ohio
Carell, W. S....Staten Island, N. Y.
Carenbauer, W. F....New Castle, Pa.
Carey, F. E........E. Orange, N. J.
Carey, P. C...........Newark, N. J.
Cargill, E. L., Jr.......Dallas, Tex.
Cargill, W. N.........Boston, Mass.
Carhart, F. M..........Boston, Mass.
Carhart, W. F.......Brooklyn, N. Y.
Caris, I. B........New York, N. Y.
Cariss, C. C....Brantford, Ont., Can.
Carle, A. B........New York, N. Y.
Carle, E. W..........Richmond, Va.
Carlin, J. A..........Detroit, Mich.
Carlisle, M.........Cincinnati, Ohio
Carlson, A. F.....Stockholm, Sweden
Carlson, A. G..........Chicago, Ill.
Carlson, A. H........Pullman, Wash.
Carlson, A. R..Northport, L. I., N. Y.
Carlson, C. A...........Moline, Ill.
Carlson, E. G....Staten Island, N. Y.
Carlson, H.........New York, N. Y.
Carlson, H. C.-R....New York, N. Y.
Carlson, H. G.*....Shrewsbury, Mass.

* Non-Member.

Carlson, H. N....Poughkeepsie, N. Y.
Carlsrud, R..........Baltimore, Md.
Carlsson, C. A. V.......Lanham, Md.
Carlton, J. R.......S. Orange, N. J.
Carlz, J. F............Manila, P. I.
Carman, E. S........Cleveland, Ohio
Carman, J. F........New York, N. Y.
Carmichael, A. J......Dayton, Ohio
Carmichael, C.........Ithaca, N. Y.
Carmoega, E. R......San Juan, P. R.
Carnegie, A.......Youngstown, Ohio
Carnegie, J., Jr.......Canton, China
Carnes, H. W......Indianapolis, Ind.
Carney, J. F.......New York, N. Y.
Carney, W. H.......New York, N. Y.
Carpenter, A. O...Painted Post, N. Y.
Carpenter, C. I.......Spokane, Wash.
Carpenter, E. L.......Kingston, R. I.
Carpenter, G. D........Ithaca, N. Y.
Carpenter, Harold...New York, N. Y.
Carpenter, Horace...Knoxville, Tenn.
Carpenter, H. A.....New York, N. Y.
Carpenter, H. B....New York, N. Y.
Carpenter, H. V......Pullman, Wash.
Carpenter, L. B., Jr......Tulsa, Okla.
Carpenter, R. C..State College, Miss.
Carpenter, T. J.....Birmingham, Ala.
Carr, A. A....St. George, S. I., N. Y.
Carr, G. E.......Jersey City, N. J.
Carr, H. H..........Richland, N. Y.
Carr, Henry R....Lackawanna, N. Y.
Carr, Hugh R..........Newark, N. J.
Carr, J. P.............Dayton, Ohio
Carrick, G. S.......New York, N. Y.
Carrier, L. L............Akron, Ohio
Carrier, W. H........Newark, N. J.
Carrington, F. G......Anniston, Ala.
Carroll, C. H......Watertown, Mass.
Carroll, E. H.....W. Boylston, Mass.
Carroll, E. J...........Glencoe, Ill.
Carroll, H. C...........Chicago, Ill.
Carroll, J. D.......New York, N. Y.
Carroll, J. F.........Dorcester, Mass.
Carroll, L. D..........London, Eng.
Carroll, M. B.......New York, N. Y.
Carroll, M. J...........Sharon, Pa.
Carse, D. B......Atlantic City, N. J.
Carson, G. B.........Cleveland, Ohio
Carson, R. W.....Little Falls, N. J.
Carson, W. H.........Norman, Okla.
Carspecken, H. L., Jr..........
S. Charleston, W. Va.
Carswell, J. M.......Fresnillo, Mex.
Carten, L. A..................
Aberdeen Proving Ground, Md.
Carter, D. S........New York, N. Y.
Carter, E. B........New York, N. Y.
Carter, F. W.......Waterbury, Conn.
Carter, G. H.......Philadelphia, Pa.
Carter, G. W..........Denver, Colo.
Carter, H. S..........Orange, Conn.
Carter, H. T.........Berkeley, Calif.
Carter, H. W............Toledo, Ohio
Carter, R. A., Jr....New York, N. Y.
Carter, R. J........New York, N. Y.
Carter, W. A..........Detroit, Mich.
Cartin, J. D......Watertown, N. Y.
Carty, M. W..........Boston, Mass.
Carty, R. F.......Washington, D. C.
Caruthers, E., Jr......Kearny, N. J.
Carver, F. S........New York, N. Y.
Carvin, F. D.........Newark, N. J.
Cary, R. W............Munhall, Pa.
Casberg, C. H...........Urbana, Ill.
Case, G. S...........Cleveland, Ohio
Case, L. B.....New Brunswick, N. J.
Case, M. C............Buffalo, N. Y.
Case, R. C..............Delhi, India
Casey, J. E.........Sayreville, N. J.
Casey, J. S........New York, N. Y.
Casey, P. N..........Auburn, N. Y.
Cash, A. W......Marshalltown, Iowa
Casiraghi, G. P...Finale Ligure, Italy
Caskey, K. H........Harrisburg, Pa.
Caskey, M. W..........St. Louis, Mo.
Casler, H..........Canastota, N. Y.
Caspell, E. E......New Haven, Conn.
Cassebeer, T...Long Island City, N. Y.
Cassell, C. W........Cedarhurst, Md.
Cassell, J. L........Ft. Worth, Tex.
Cassidy, P.........New York, N. Y.
Cassidy, P. F.Floral Park, L. I., N. Y.
Cassidy, T. F., Jr....Hartford, Conn.
Cassity, J. C.............Arp, Tex.
Cassotti, M........New York, N. Y.
Castellano, F. S......Irvington, N. J.
Castle, D. W.............Joliet, Ill.
Castle, K. B........Rochester, N. Y.
Castle, S. N.........Honolulu, T. H.
Castro, H. E.......Rutherford, N. J.
Cather, J. H.........Rochester, N. Y.
Cattaneo, G..................Milan, Italy
Cattermole, L. G...............
Lynnfield Center, Mass.
Catts, G. R., Jr.Ft. Sam Houston, Tex.
Caudel, F. H........Martinez, Calif.
Caughey, R. J....Schenectady, N. Y.
Cavanaugh, J. P....Philadelphia, Pa.
Cave, J. R., Jr...Bayside, L. I., N. Y.
Cavin, G........Kingston, Ont., Can.
Cawley, G.....Upper Montclair, N. J.
Caywood, T. G.......Iowa City, Iowa
Cecil, R. E............Oakmont, Pa.
Cerny, W. J.....W. Hollywood, Calif.
Cervino, M. P........Paterson, N. J.
Cetrule, J...........New York, N. Y.
Chace, W. F.........Medford, Mass.
Chadwick, L. S.......Cleveland, Ohio
Chafee, J. S........Providence, R. I.
Chaffe, W. H..........Kenosha, Wis.
Chaffin, W. L.......Wheeling, W. Va.
Chalikian, E. M....Philadelphia, Pa.
Chalkey, C. R.........Cincinnati, Ohio
Chalkley, Henry G..Lake Charles, La.
Chalkley, Henry G., Jr..........
Lake Charles, La.
Challender, R. T.....Bozeman, Mont.
Chalmers, J. B........Stamford, Conn.
Chamberlain, A. S...New York, N. Y.
Chamberlain, G. L..Watertown, N. Y.
Chamberlain, L. H.Los Angeles, Calif.
Chamberlain, P. M.....Newark, N. J.
Chamberlain, W. T...Brooklyn, N. Y.
Chambers, C. E........Roselle, N. J.
Chambers, D. F.........Chicago, Ill.
Chambers, E. G.....Philadelphia, Pa.
Chambers, H. E., Jr.....Dallas, Tex.
Chambers, N. C.....New York, N. Y.
Chambers, W. H., Jr..........
Las Cruces, New Mex.
Chambers, W. R.....Knoxville, Tenn.
Champion, C. H........London, Eng.
Champion, E. L.........Chicago, Ill.
Champney, R. P......Detroit, Mich.
Chandler, C. A..E. Bridgewater, Mass.
Chandler, H. M........Grasselli, N. J.
Chandler, L. D........Boston, Mass.
Chandler, R.......Indianapolis, Ind.
Chang, K. H.........New York, N. Y.
Channappa, B. K....Bhadravati, India
Chapell, A. R.......Stamford, Conn.
Chapin, E. A.......Flat Rock, Mich.
Chapin, Geo. W....Mill Valley, Calif.
Chapin, W. W.......New York, N. Y.
Chaplin, J. H........Hartford, Conn.
Chaplin, M. P..........Portland, Me.
Chapman, A. H.......Osborne, Aust.
Chapman, C. M.....New York, N. Y.
Chapman, E.........Coatesville, Pa.
Chapman, K. B....Providence, R. I.
Chapman, R. G.......Durham, N. C.
Chapman, R. H.....Greenville, S. C.
Chapman, W. W........Newark, N. J.
Chaput, A. J..........Denver, Colo.
Charavay, M. A.....New York, N. Y.
Chard, T. B........Brookline, Mass.
Charles, C. L...........Chicago, Ill.
Charlton, K. G....Emeryville, Calif.
Charlton, R. C.....Philadelphia, Pa.
Charnley, T. L......Cambridge, Mass.
Charno, J..........Binghamton, N. Y.
Charter, J. A...........Chicago, Ill.
Chase, C. H......Tufts College, Mass.
Chase, E. A..........Suncook, N. H.
Chase, F. S.......Waterbury, Conn.
Chase, H. H........New York, N. Y.
Chase, J. D..........Cleveland, Ohio
Chase, L. A........Waterbury, Conn.
Chase, P. H........Philadelphia, Pa.
Chase, R. C.......Waterbury, Conn.
Chason, D. H.......Elizabeth, N. J.
Chatard, W. M.......Baltimore, Md.
Chater, J. A...........Medina, N. Y.
Chatfield, H.....Minneapolis, Minn.
Chattey, J. K..........Dallas, Tex.
Chave, C. T........New York, N. Y.
Chave, W. E........New York, N. Y.
Chawla, S. H..........Lahore, India
Chawner, W. R........Corona, Calif.
Cheal, W. C....San Francisco, Calif.
Cheetham, J. H........Toledo, Ohio
Cheever, M.........New York, N. Y.
Cheever, P............Detroit, Mich.
Chen, W. C..........Shanghai, China
Cheney, F., Jr....Manchester, Conn.
Cheney, N...........Belmont, Mass.
Chepeleff, N...........Salem, Mass.
Cherdantzeff, P......New York, N. Y.
Chesler, I..........New York, N. Y.
Chesney, M. M......Pittsfield, Mass.
Chess, G. E...........Fresno, Calif.
Chester, H. D........Manapla, P. I.
Chester, J. N.........Pittsburgh, Pa.
Chester, R. G.......Glendale, Calif.
Chester, T............London, Eng.
Chetty, B. K.........Bangalore, India
Cheyney, A. R.....Washington, D. C.
Chick, A. C......Providence, R. I.
Chickering, J. A.....Elizabeth, N. J.
Chiffelle, F. A......Slatersville, R. I.
Childs, C. W......Waterbury, Conn.
Childs, E. W., Jr...Providence, R. I.
Childs, H. B.......Providence, R. I.
Chion, F. V........New York, N. Y.
Chipman, F. W...Framingham, Mass.
Chiras, D...........Springfield, Mass.
Chisholm, C. R.......Baltimore, Md.
Chittenden, G. I.......Cleveland, Ohio
Chivens, C. C........Burbank, Calif.
Choraso, Z..Amsterdam, Netherlands
Chrisman, J. L....Los Angeles, Calif.
Christensen, C. H...New York, N. Y.
Christensen, W. P......London, Eng.
Christiansen, P......Alameda, Calif.
Christianson, A.........Chicago, Ill.
Christie, A. G........Baltimore, Md.
Christie, E. W.......Tacoma, Wash.
Christie, R. W......Kansas City, Mo.
Christie, W. D.....Ridgewood, N. J.
Christie, W. E.......Waukesha, Wis.
Christman, C. J.......Houston, Tex.
Christman, J. W......Oak Park, Ill.
Christy, W. G......Jersey City, N. J.
Chryst, W. A..........Dayton, Ohio
Chun, E. H. J..........Chicago, Ill.
Church, A. H.......New York, N. Y.
Church, E. F., Jr.....Brooklyn, N. Y.
Church, H. D........Cleveland, Ohio
Church, M. D......Wellesville, N. Y.
Churchill, A. J...Prospect Park, Pa.
Churchill, A. W...............
Glen Cove, L. I., N. Y.
Churchill, G. E......Stamford, N. Y.
Churchill, W. L....New York, N. Y.
Chute, S. J.........New York, N. Y.
Chwang, C.-T.........Peiping, China
Ciapinski, C. J...........Cicero, Ill.
Cilia, O. J........Greenwich, Conn.
Cilley, R...........New York, N. Y.
Cincotta, J. J.......N. Bergen, N. J.
Cintron, G. E...............
Central Mercedita, P. R.
Cioffi, M. V...........Everett, Mass.
Cislak, J. F...........Evanston, Ill.
Cisler, W. L..........Newark, N. J.
Ciulla, J. D.........Brooklyn, N. Y.
Cizek, A. W., Jr....New York, N. Y.
Cizek, J. J...........Passaic, N. J.
Clade, R...............Detroit, Mich.
Clancy, J. R..Long Island City, N. Y.
Clapp, L. R.........Seymour, Conn.
Clapp, W. H........Pasadena, Calif.
Clarage, H. L.........Sutter, Calif.
Clark, A. B...........Chicago, Ill.
Clark, Addison L.San Francisco, Calif.
Clark, Albert L........Durham, N. C.
Clark, A. M..........Portland, Ore.
Clark, C. G......St. John, N. B., Can.
Clark, D...............Lorain, Ohio
Clark, D. S.........Pasadena, Calif.
Clark, E. D................York, Pa.
Clark, E. E..........Brooklyn, N. Y.
Clark, F. C...........Hopewell, Va.
Clark, F. G........Baton Rouge, La.
Clark, F. H.........New York, N. Y.
Clark, F. S...........Boston, Mass.
Clark, G. S.....San Francisco, Calif.
Clark, H. W...........Denver, Colo.
Clark, I. W.........Bethany, Conn.
Clark, J. D...........Hampton, Va.
Clark, J. E........Rensselaer, N. Y.
Clark, J. M........New York, N. Y.
Clark, M. H..........Boston, Mass.
Clark, P. J.........New York, N. Y.
Clark, R. E..........Cleveland, Ohio
Clark, R. W.....Salt Lake City, Utah
Clark, S. C.........New York, N. Y.
Clark, S. W..........Tampico, Mex.
Clark, T. F........Philadelphia, Pa.
Clark, W...............Paris, France
Clark, W. H. D..Montreal, Que., Can.
Clark, Walter L., Jr......Akron, Ohio
Clark, Walter L.....New York, N. Y.
Clark, W. R........Bridgeport, Conn.
Clark, W. W........N. Adams, Mass.
Clarke, A. W........St. Charles, Mo.
Clarke, C. A...........Hudson, Mass.
Clarke, C. E.....Sparrows Point, Md.
Clarke, C. L...........Newton, Mass.
Clarke, C. M.........New York, N. Y.
Clarke, C. W............Parel, India
Clarke, C. W. E.....Philadelphia, Pa.
Clarke, E. B..........Camas, Wash.
Clarke, E. C.....Chambersburg, Pa.
Clarke, F. F..........Franklin, Pa.
Clarke, J. B......Welland, Ont., Can.
Clarke, M. H.....White Plains, N. Y.
Clarke, P. C...........Lansdale, Pa.
Clarke, P. L..........Glendale, Calif.
Clarke, S. G......Toronto, Ont., Can.
Clarke, W. H..........Chicago, Ill.
Clarke, W. J........New York, N. Y.
Clary, F. A., Jr....Englewood, N. J.
Clary, W. B........Harrison, N. J.
Clausen, A. W......San Mateo, Calif.
Clausen, H. C.........Swissvale, Pa.
Clausen, J...........Harrisburg, Pa.
Clausen, J. C........Seattle, Wash.
Clauss, C. A.......Bloomfield, N. J.
Clauss, J. A..........Detroit, Mich.
Claypoole, A...........Chicago, Ill.
Clayton, J. P...........Chicago, Ill.
Clayton, L. J....Toronto, Ont., Can.
Cleaveland, N.........Benicia, Calif.
Cleavenger, W. D.....Hammond, Ind.
Cleeves, W. D.........Oakmont, Pa.
Clegg, W. H....Montreal, Que., Can.
Cleghorn, M. P...........Ames, Iowa
Clem, D. W.........New York, N. Y.
Clem, W. M........Birmingham, Ala.
Clemens, A. B.........Scranton, Pa.
Clemens, A. W.......Bethlehem, Pa.
Clemens, W. F.......Detroit, Mich.
Clement, W. J.........Utica, N. Y.
Clements, B. M......Aruba, D. W. I.
Clemmer, A. J......New York, N. Y.
Cleveland, F. W......Hartford, Conn.
Clifford, E. L..........Detroit, Mich.
Clinedinst, W. O.......Canton, Ohio
Clinedinst, W. W....New York, N. Y.
Clingerman, R. L..Washington, D. C.
Clisham, F. R....San Anselmo, Calif.
Clo, H. E..............Louisville, Ky.
Clock, E. E...........Passaic, N. J.
Closs, G. M.............Toledo, Ohio
Clouse, J. H......Coral Gables, Fla.
Clousing, L. A.........Evanston, Ill.
Clovis, E. J.........Milwaukee, Wis.
Clucas, G. W..........Chicago, Ill.
Cluett, A. E.............Troy, N. Y.
Cluett, S. L.............Troy, N. Y.
Clune, J. P.........Syracuse, N. Y.
Clurman, W. N.
Rockville Center, L. I., N. Y.
Clyde, J. D..........Texarkana, Tex.
Coakley, W. E.......Milwaukee, Wis.
Coates, H. T........New York, N. Y.
Coates, W............Newark, N. J.
Cobb, E. T..............S. Bend, Ind.
Cobb, H. E........Philadelphia, Pa.
Cobb, J. A., Jr....Wichita Falls, Tex.
Cobb, L. A.......Minneapolis, Minn.
Cobb, W. H...........Passaic, N. J.
Coberly, C. J.....Los Angeles, Calif.
Coburn, D. W..........Kearny, N. J.
Coburn, F. G........New York, N. Y.
Coburn, P. J......Chattanooga, Tenn.
Cochran, A. R......Canovanas, P. R.
Cochran, F. J......New Haven, Conn.
Cochran, W. B........Houston, Tex.
Cochrane, L.....Babylon, L. I., N. Y.
Cockburn, L. S.........Detroit, Mich.
Cocke, M. E, Jr.....Elizabeth, N. J.
Cockins, W. W., Jr............
San Francisco, Calif.
Codding, E. H......New York, N. Y.
Codrington, G. W....Cleveland, Ohio
Coe, F. C..........Philadelphia, Pa.
Coe, J. A..........Waterbury, Conn.
Coe, R. S..........Cromwell, Conn.
Coes, H. V.........New York, N. Y.
Coffin, F. M.........New York, N. Y.
Coffin, G. S..Newton Highlands, Mass.
Coffin, H. E.........New York, N. Y.
Coffin, L. F.....Sparrows Point, Md.
Coghlan, S. F....Santa Monica, Calif.
Cogswell, J. B........Mazatlan, Mex.
Cohen, A. A...........Scranton, Pa.
Cohen, A. E............Chicago, Ill.
Cohen, A. S.............Boston, Mass.
Cohen, B.............Brooklyn, N. Y.
Cohen, E. F.........New York, N. Y.
Cohen, E. M........New York, N. Y.
Cohen, I............Elizabeth, N. J.
Colbert, T. P.........Madison, Wis.
Colby, A. B...........Newark, N. J.
Colby, E. W............Perry, Mich.
Colby, H. L...........Boston, Mass.
Colby, H. S........New York, N. Y.
Coldwell, E. S......New York, N. Y.
Cole, A. L.......Regina, Sask., Can.
Cole, A. W.......W. Lafayette, Ind.
Cole, B. B.........San Diego, Calif.
Cole, C. B..............Chicago, Ill.
Cole, C. S.........New York, N. Y.
Cole, E. S..........New York, N. Y.
Cole, F. B.........Winchester, Mass.
Cole, G. N.........E. Hartford, Conn.
Cole, H..............Birmingham, Ala.
Cole, J. H..........Richmond, Calif.
Cole, K. W..............Chicago, Ill.
Cole, L. C..........Hamilton, Ohio
Cole, L. S.............Dallas, Tex.
Cole, P. H...........Brooklyn, N. Y.
Cole, P. W.............Danville, Pa.
Cole, R. A.........E. Lansing, Mich.
Cole, R. W...........Attleboro, Mass.
Cole, S. I...............Chicago, Ill.
Coleman, E. L..........Chicago, Ill.
Coleman, F. A......New York, N. Y.
Coleman, H. F......New Orleans, La.
Coleman, H. S.......Pittsburgh, Pa.
Coleman, J. B......Providence, R. I.
Coleman, M. B......Carrolltown, Pa.

Coleman, P. L.......New York, N. Y.
Coleman, W. W...S. Milwaukee, Wis.
Colgate, S. B......State College, Pa.
Colles, G. W.........Rosharon, Tex.
Collet, L. G........Columbus, Ohio
Colley, C. J.........St. Louis, Mo.
Colley, C. T......Los Angeles, Calif.
Colliander, C. T....Providence, R. I.
Collier, W. I.........Baltimore, Md.
Collins, B. R. T. Newton Centre, Mass.
Collins, C. H.....Los Angeles, Calif.
Collins, F. A.......Ann Arbor, Mich.
Collins, F. W.......Berkeley, Calif.
Collins, G. A....San Francisco, Calif.
Collins, J., Jr.......Brooklyn, N. Y.
Collins, J. A..........Boston, Mass.
Collora, N. A.......New York, N. Y.
Colpitts, J. V.....Philadelphia, Pa.
Colson, E. G..Long Island City, N. Y.
Colson, J. H...........Omaha, Neb.
Colston, R.............Chicago, Ill.
Colville, W. T., Jr...Riverside, Calif.
Colvin, C. H......Morristown, N. J.
Colvin, F. H........New York, N. Y.
Colvin, J. A......Minneapolis, Minn.
Colvin, T. E....San Francisco, Calif.
Combe, F. A....Montreal, Que., Can.
Comly, G. N...Moylan-Rose Valley, Pa.
Compton, A. S......Collingdale, Pa.
Compton, K. T......Cambridge, Mass.
Compton, P..........St. Louis, Mo.
Compton, R. B.......St. Louis, Mo.
Comstock, C. W..............
Jackson Heights, L. I., N. Y.
Comstock, L. K......New York, N. Y.
Conant, W. S......Washington, D. C.
Conard, W. R......Burlington, N. J.
Condit, K. H.......New York, N. Y.
Condron, M. M......Zanesville, Ohio
Cone, H. I........Washington, D. C.
Congdon, J. E......Providence, R. I.
Conhagen, A.........New York, N. Y.
Conley, John W.......Detroit, Mich.
Conley, John W.....Palo Alto, Calif.
Conlon, W. T........New York, N. Y.
Conn, T. D..........Baltimore, Md.
Connell, F. G.........Leechburg, Pa.
Connell, P. C..........Boston, Mass.
Connelly, J. R........Bethlehem, Pa.
Connelly, W. C......Cleveland, Ohio
Conner, J. L......Upper Darby, Pa.
Conner, K. B.......Philadelphia, Pa.
Conner, N. W.........Blacksburg, Va.
Connery, W. H., Jr....Clinton, Mass.
Connolly, J. H......Providence, R. I.
Connolly, J. W.....New York, N. Y.
Connon, G. W......Los Mochis, Mex.
Connor, N. J........New York, N. Y.
Connor, W. H.....Schenectady, N. Y.
Conover, F. H.....New York, N. Y.
Conrad, C. W......E. Walpole, Mass.
Conrad, H. V........New York, N. Y.
Conrad, W. A........Cleveland, Ohio
Conrad, W. L......Washington, D. C.
Conran, F. M..........Hillside, N. J.
Constam, A. F......Cleveland, Ohio
Constantinescu, V............
Lethbridge, Alta., Can.
Conta, L. D.........Rochester, N. Y.
Contant, P. M......New York, N. Y.
Conterman, F. A...Jamestown, N. Y.
Converse, B. T.....Wilmington, Del.
Conway, G. R. G......Mexico, Mex.
Conway, M. J. T....Coatesville, Pa.
Coogan, C. H., Jr...Philadelphia, Pa.
Cook, A. M..........Worcester, Mass.
Cook, C. B..........Hartford, Conn.
Cook, E. L...........Danvers, Mass.
Cook, E. S.........Wilmerding, Pa.
Cook, F. C......Sparrows Point, Md.
Cook, F. L.........Brooklyn, N. Y.
Cook, G., Jr.......Philadelphia, Pa.
Cook, G. C..........Brooklyn, N. Y.
Cook, H. E.............Akron, Ohio
Cook, H. L.......Washington, D. C.
Cook, H. M..........Brooklyn, N. Y.
Cook, H. R., Jr......Baltimore, Md.
Cook, L. A.........New York, N. Y.
Cook, M. A..............Troy, N. Y.
Cook, O. B........New York, N. Y.
Cook, R. W..........Bristol, Conn.
Cook, T. J..St. Catherines, Ont., Can.
Cook, T. R.........Philadelphia, Pa.
Cook, Wm. D..........Detroit, Mich.
Cook, Willis D.....Marysville, Calif.
Cook, W. G..........Warrenton, Ore.
Cook, W. H., Jr.......Boston, Mass.
Cook, W. P., Jr.....New York, N. Y.
Cooke, B. W...........Glencoe, Ill.
Cooke, H..............Auburn, N. Y.
Cooke, J. C.......Chappaqua, N. Y.
Cooke, M. L......Philadelphia, Pa.
Cooke, W. F.........Richmond, Va.
Cookson, L. T.........Nutley, N. J.
Cool, K. A..........Cleveland, Ohio
Cooley, E. S.........Westfield, N. J.
Cooley, M. E...........Detroit, Mich.

Coolidge, C. E.........Atlanta, Ga.
Coolidge, R. N.......Nashville, Tenn.
Coombs, R. R......Youngstown, Ohio
Coon, J. S..............Atlanta, Ga.
Coon, T. E...........Detroit, Mich.
Cooney, F. J.........New York, N. Y.
Coonley, H.........New York, N. Y.
Coonradt, A. C......New York, N. Y.
Coons, H. W., Jr.....Brooklyn, N. Y.
Cooper, B..........New York, N. Y.
Cooper, E.............Decatur, Ill.
Cooper, E. G.......Pittsfield, Mass.
Cooper, F. F.....San Francisco, Calif.
Cooper, F. P......New York, N. Y.
Cooper, G. H.......Hartford, Conn.
Cooper, H..........New York, N. Y.
Cooper, H. C.........Pittsburgh, Pa.
Cooper, H. L.......New York, N. Y.
Cooper, J. McG., Jr..Philadelphia, Pa.
Cooper, R. D..........Chicago, Ill.
Cooper, R. F........Rochester, N. Y.
Cooper, R. S............Chicago, Ill.
Cooper, S. J....Montreal, Que., Can.
Cooper, W. B..............Rome, Ga.
Cooper, W. C...........Austin, Tex.
Cooper, W. S........Brooklyn, N. Y.
Cope, E. T..............Detroit, Mich.
Cope, W. J.....Salt Lake City, Utah
Copley, LeR. B......Norwich, N. Y.
Copp, E. M..........San Juan, P. R.
Copp, R...............St. Louis, Mo.
Coppersmith, C. W...Cleveland, Ohio
Coppersmith, F. M...Brooklyn, N. Y.
Coppock, R. K...........Troy, Ohio
Coppock, W. J.....Philadelphia, Pa.
Corbin, F. D........North Hills, Pa.
Corby, J. B...........St. Louis, Mo.
Cordell, P. M........Ft. Worth, Tex.
Corell, G. W............Chicago, Ill.
Corey, D. H...........Detroit, Mich.
Corey, F. B..........Barberton, Ohio
Corinth, T..........New York, N. Y.
Cork, L. C.........Birmingham, Ala.
Corl, H. E.........Upper Darby, Pa.
Cornelius, C. T..............
Shawinigan Falls, Que., Can.
Cornelius, H. R......Pittsburgh, Pa.
Cornelius, L. A..Grand Rapids, Mich.
Cornell, D. R.......E. Chicago, Ind.
Cornell, E. S., Jr...Larchmont, N. Y.
Cornell, R. L..........Sanford, Fla.
Cornell, W. B.......Montclair, N. J.
Cornell, W. R...........Ithaca, N. Y.
Cornish, D. F. New Toronto, Ont., Can.
Cornish, W. R........Duluth, Minn.
Cornog, R............Iowa City, Iowa
Cornwell, D. R. L.......Chicago, Ill.
Cornwell, H. V.....New York, N. Y.
Corsini, U. F.......Worcester, Mass.
Corson, D. C........Ft. Smith, Ark.
Cortelyou, C. G...Los Angeles, Calif.
Cortes, J. M..Bogota, Colombia, S. A.
Corwin, E. F............Troy, N. Y.
Cory, D. C.........New York, N. Y.
Coryea, C. E..........Portland, Ore.
Cosden, E. D........Harrisburg, Pa.
Cosin, N...........Los Angeles, Calif.
Coster, E. H.......New York, N. Y.
Cother, A. A..Navosibersk, U. S. S. R.
Cothran, J. S.......Charlotte, N. C.
Cotlin, J. W......Birmingham, Ala.
Cotta, R. L........Philadelphia, Pa.
Cotter, G. L.........Wilmerding, Pa.
Cotterell, W. J..Johannesburg, Africa
Cotterman, F. D........Chicago, Ill.
Cottle, A. P...........Chicago, Ill.
Cotton, G. G.......Pasadena, Calif.
Cotton, H. McL........Dallas, Tex.
Cotton, H. W....Jamaica, L. I., N. Y.
Cottrell, N..........New York, N. Y.
Cotty, W. O...........Richmond, Va.
Couch, A. D...Upper Montclair, N. J.
Couch, D. H........Shanghai, China
Couchman, V. C.........Dania, Fla.
Coulson, H. G.......Honolulu, T. H.
Coulson, H. H.......Brooklyn, N. Y.
Coulter, E. B........Richmond, Va.
Coupal, E. A.........Medford, Mass.
Courtenay, C. R...Watertown, N. Y.
Cover, R. W.........Harrisburg, Pa.
Covey, K. S.........New York, N. Y.
Covino, A. O....W. New York, N. J.
Cowan, B.......Dolbeau, Que., Can.
Cowan, F................Perry, Iowa
Cowell, W. T.......Rochester, N. Y.
Cowgill, W. W....Jersey City, N. J.
Cowles, C. A., Jr.........Dallas, Tex.
Cox, Abraham B.....New York, N. Y.
Cox, Anthony B......Pittsburgh, Pa.
Cox, C. E..............Franklin, Pa.
Cox, C. G.............Oakland, Calif.
Cox, E. L........Washington, D. C.
Cox, F. G..........Edge Moor, Del.
Cox, J. L..........Philadelphia, Pa.
Cox, J. W.........New York, N. Y.
Cox, S. F..............Detroit, Mich.
Cox, S. J..........Tonawanda, N. Y.

Cox, W. P............Canton, Ohio
Coxe, N. Y......Schenectady, N. Y.
Coyne, T. D..........Elmhurst, N. Y.
Cozad, M. D......Seneca Falls, N. Y.
Cozzens, J. H........New York, N. Y.
Cozzo, S. E.....San Francisco, Calif.
Crabb, G. H...........Boston, Mass.
Craft, H. W., Jr.......St. Louis, Mo.
Crafts, C. S............Chicago, Ill.
Crafts, I. M...........Portland, Conn.
Craig, D. P.........Ft. Collins, Colo.
Craig, H. B............Solvay, N. Y.
Craig, J.........New Rochelle, N. Y.
Craig, J. G............Pontiac, R. I.
Craig, J. S..........Barberton, Ohio
Craig, O............Worcester, Mass.
Craig, R............New York, N. Y.
Crain, H. F........Ottawa, Ont., Can.
Crain, H. L.........Kansas City, Mo.
Crain, J. J........Wallingford, Conn.
Crain, L. D.........Ft. Collins, Colo.
Cramer, J..........Emeryville, Calif.
Cramer, J. L..........Buffalo, N. Y.
Cramer, L. W.......The Dalles, Ore.
Cramer, W. G......Cincinnati, Ohio
Cramp, A. P.............Akron, Ohio
Crandall, J. R...Stanford Univ., Calif.
Crane, E. C.........Cleveland, Ohio
Crane, E. J............Chicago, Ill.
Crane, F................Dallas, Tex.
Crane, H. M.........New York, N. Y.
Crane, H. P.........Worcester, Mass.
Crane, J. B..........Pittsburgh, Pa.
Crane, R. L., Jr........Buffalo, N. Y.
Crater, M. L.........Pasadena, Calif.
Craven, G. W...........Butte, Mont.
Cravens, G. W......New York, N. Y.
Crawford, A. B......Brooklyn, N. Y.
Crawford, C. C......New Orleans, La.
Crawford, C. H......New York, N. Y.
Crawford, C. W...College Station, Tex.
Crawford, D. F.......Pittsburgh, Pa.
Crawford, P. O..........Chicago, Ill.
Crawford, T. G....Schenectady, N. Y.
Crawford, W. W.....E. Chicago, Ind.
Crawley, G. E.......Francisco, Cuba
Creamer, V. A.....Watertown, Mass.
Crede, C. E..........Pittsburgh, Pa.
Credo, J..............Louisville, Ky.
Creighton, W. S......Pittsburgh, Pa.
Crenshaw, B. W.....Chillicothe, Mo.
Crenshaw, R. A.....Greenwood, Miss.
Crepeault, H. F......Newport, R. I.
Cressy, M. S., Jr.....Plainfield, N. J.
Crewdson, H.......Marcus Hook, Pa.
Crewson, G. G.........Buffalo, N. Y.
Crimp, G. B.........Brooklyn, N. Y.
Crisante, A. M.....Morristown, N. J.
Crissey, C. P.........Trenton, N. J.
Criswell, W. W., Jr..New York, N. Y.
Critchlow, H. T., Jr...Lancaster, Pa.
Crocker, A. R.....E. Hartford, Conn.
Crocker, A. S........Rochester, N. Y.
Crocker, E. B.....Bridgeport, Conn.
Crocker, P. B.......Foxboro, Mass.
Crocker, S............Detroit, Mich.
Crockett, C. H..........Troy, N. Y.
Crockett, H. G......New York, N. Y.
Crockford, R. H.....Charlotte, N. C.
Crofoot, G. E......Philadelphia, Pa.
Croft, D. R.........Columbus, Ohio
Croft, H. O..........Iowa City, Iowa
Croghan, J. T......Cambridge, Mass.
Croll, A. G....Upper Montclair, N. J.
Croll, R. H...........Buffalo, N. Y.
Cromwell, H. T......Pittsburgh, Pa.
Cromwell, O. C.......Baltimore, Md.
Cronemeyer, H. C.....Aliquippa, Pa.
Cronin, F. H..........Yorklyn, Del.
Cronin, P. L..........Detroit, Mich.
Cronvich, J. A......New Orleans, La.
Cropper, R. O........Lexington, Ky.
Crosby, E. S........New York, N. Y.
Crosby, G. F., Jr......Bayonne, N. J.
Crosby, J.....Long Island City, N. Y.
Cross, B. J.........New York, N. Y.
Cross, G. P. S..........Beverly, Mass.
Cross, H. W...........Chicago, Ill.
Cross, R. A............Moline, Ill.
Cross, R. C..........Columbus, Ohio
Cross, W. J............Chicago, Ill.
Crossan, T. E......Baton Rouge, La.
Crossley, W. C..........Athens, Pa.
Crossman, A.........Brooklyn, N. Y.
Crotty, J. J........New York, N. Y.
Crouch, C. H.......Grantwood, N. J.
Crouch, M. L., Jr......Lockwood, Ohio
Crovatto, P. R.....New York, N. Y.
Crowder, W. L........Pueblo, Colo.
Crowdus, R. R..........Dallas, Tex.
Crowell, H. W.........Newark, N. J.
Crowley, C. L......Philadelphia, Pa.
Crowley, C. P.......Alhambra, Calif.
Crowley, H. L......W. Orange, N. J.
Crowley, J. J........Brooklyn, N. Y.
Crowley, J. M. Long Island City, N. Y.
Crownover, J. C......Greensburg, Pa.

Crowther, G. A..............
Long Island City, N. Y.
Crowther, J. G....Clarksburg, W. Va.
Crozier, H. W..San Francisco, Calif.
Cruickshanks, B. C. Washington, D. C.
Cruikshank, B.........Seattle, Wash.
Cruise, J. H..........Newark, N. J.
Crull, H. R...........Louisville, Ky.
Crum, S..........Minneapolis, Minn.
Crump, N. R.....Regina, Sask., Can.
Crute, W. R..........Pasadena, Tex.
Csisek, J. J......Phillipsburg, N. J.
Cucullu, L. J.......New Orleans, La.
Cuddeback, A. E....New York, N. Y.
Cuff, H. B........Little Falls, N. J.
Culbertson, D..........Topeka, Kan.
Cullen, T. J..........New York, N. Y.
Culler, C. D........Ft. Collins, Colo.
Cullimore, A. R....S. Orange, N. J.
Culp, S. K............Allentown, Pa.
Culver, E. P........Princeton, N. J.
Culver, H. F...........Chicago, Ill.
Cummings, F. S..San Francisco, Calif.
Cummings, J. D.....New York, N. Y.
Cummings, L. A...Jamestown, N. Y.
Cummings, O. P....New York, N. Y.
Cummings, R. A.........Athol, Mass.
Cummings, R. F....New York, N. Y.
Cummings, S. R.......N. Canton, Ohio
Cummins, C. L.......Columbus, Ind.
Cummins, N. W.......Louisville, Ky.
Cummiskey, W. M.....Newark, N. J.
Cumner, M. S......New York, N. Y.
Cunning, J., Jr....Indianapolis, Ind.
Cunningham, F........Lowell, Mass.
Cunningham, G. A...........
Peterboro, Ont., Can.
Cunningham, G. H.....Danville, Va.
Cunningham, J. D.......Chicago, Ill.
Cunningham, J. F., Jr..Detroit, Mich.
Cunningham, J. S.......Chicago, Ill.
Cunningham, R. O.....Detroit, Mich.
Cuomo, F.....Aqueduct, L. I., N. Y.
Curioni, S. M.......New York, N. Y.
Curley, M. H..Bay Shore, L. I., N. Y.
Curran, R. W.......Little Rock, Ark.
Curren, R. L.....Staten Island, N. Y.
Curreri, R. I.........Brooklyn, N. Y.
Currey, J. J........Jersey City, N. J.
Currie, F. J........Carson City, Nev.
Currier, C. H..........Buffalo, N. Y.
Currier, D. C........Mishawaka, Ind.
Currier, H. L.........Brooklyn, N. Y.
Curro, F. C..........Brooklyn, N. Y.
Curry, E. B..........St. Paul, Minn.
Curry, M...........New York, N. Y.
Curtis, A. B....French Camp, Miss.
Curtis, E. H., Jr.....Cincinnati, Ohio
Curtis, L. D...........Seattle, Wash.
Curtis, R. E............Boston, Mass.
Curtis, W. H..........Dayton, Ohio
Curtiss, C. B........Bay City, Mich.
Curtiss, W. L.......New York, N. Y.
Cushing, H. J.......New York, N. Y.
Cushing, H. M........Buffalo, N. Y.
Cushing, R. A..........Boston, Mass.
Cushing, T. E......Philadelphia, Pa.
Cushman, P. A......Valparaiso, Ind.
Custer, R.........Lackawanna, N. Y.
Cuthbert, I. N.....Ann Arbor, Mich.
Cutler, A. E...........Norton, Mass.
Cutler, J. B..........Baltimore, Md.
Cutler, W. M.......Cambridge, Mass.
Cutten, L. H.........Allentown, Pa.
Cutter, G. A.............Lynn, Mass.
Cutting, F. S.......Providence, R. I.
Cyphers, J. F.......Maplewood, N. J.
Czajkowski, E. C.......Chicago, Ill.
Czerwinski, F. A....Jersey City, N. J.
Czock, J. H.......Long Beach, Calif.

D

Daasch, F. J........Rock Island, Ill.
Daasch, H. L............Ames, Iowa
Dabanoff, R........Syracuse, N. Y.
Dabney, J. C., Jr......Lynchburg, Va.
Dacanay, B. R....Washington, D. C.
da Costa, G.............Parel, India
Daddario, F. T...Schenectady, N. Y.
Dadley, J. W.......Philadelphia, Pa.
Dahlgren, C. E..........Chicago, Ill.
Dahlstrand, H.......Milwaukee, Wis.
Dahlund, E. L...........Beloit, Wis.
Dahm, W. B..........Belleville, Ill.
Dailey, W. H., Jr....Pittsburgh, Pa.
Dakin, R. Y......Los Angeles, Calif.
Dale, D. N...........Winnfield, La.
Dale, D. W...............Wayne, Pa.
Dale, R. B...........Brooklyn, N. Y.
Daleda, J..........Fall River, Mass.
Daley, R. E...........Jerome, Idaho
Dall, A. H.........Cincinnati, Ohio
Dallas, C. F...........Havana, Cuba
Dallas, J..........Philadelphia, Pa.

Dallett, E..........Philadelphia, Pa.
Dalrymple, A. W..............
Barranquilla, Colombia, S. A.
Dalsheimer, H........Baltimore, Md.
Dalton, H. H.......New York, N. Y.
Dalton, T. E.......New York, N. Y.
Dalton, W........Schenectady, N. Y.
Daly, E. J.........Waterbury, Conn.
Dalziel, P. S...........Chicago, Ill.
Dam, C. K.....San Francisco, Calif.
Dame, E. A.......Champlain, N. Y.
Dame, F. E.........New York, N. Y.
Damon, J. H.........Plymouth, Mass.
Dana, B. P.............Lynn, Mass.
Danel, P...........Grenoble, France
Danforth, R. H......Cleveland, Ohio
Danforth, R. S...San Francisco, Calif.
Daniel, K. R......Birmingham, Ala.
Daniels, Chas. W...Philadelphia, Pa.
Daniels, Clarence W..Worcester, Mass.
Daniels, D. V......Rivesville, W. Va.
Daniels, F. H.......Worcester, Mass.
Daniels, G. C..........Jackson, Mich.
Danielsen, J. E........St. Louis, Mo.
Dann, W. J........Des Moines, Iowa
Dannemann, H., II...New York, N. Y.
Dannettel, R. C.......Baltimore, Md.
Dannettell, H. W..Takoma Park, Md.
Darbee, W..........New York, N. Y.
Darby, I. H., Jr....Kansas City, Kan.
Darby, J............Summit, N. J.
D'Arcey, A. C....Swampscott, Mass.
D'Arcy, A. J.......New York, N. Y.
D'Arcy, F. G.....Southbridge, Mass.
Darling, E. E.........Detroit, Mich.
Darling, K. M.............Erie, Pa.
Darling, P. G........Stratford, Conn.
Darlington, J. F........Chicago, Ill.
Darnold, E. E.......Kansas City, Mo.
Darrah, W. A..........Chicago, Ill.
Darrow, W. E., Jr..E. Hartford, Conn.
Dart, H. E...........Hartford, Conn.
Dart, T. P.............Chicago, Ill.
Dart, W. C.........Providence, R. I.
Das, P.............Peekskill, N. Y.
Dashefsky, G. J.....Brooklyn, N. Y.
Dashiell, W. W......New York, N. Y.
Dasso, D...........New York, N. Y.
Dauber, C. A........Cleveland, Ohio
Daugherty, F......Philadelphia, Pa.
Daugherty, R. L.....Pasadena, Calif.
Daugherty, S. B........Oil City, Pa.
Davenport, G.........E. Orange, N. J.
Davenport, J. F.....San Diego, Calif.
Davenport, W. S.....Rochester, N. Y.
Davey, G. W.......Worcester, Mass.
Davey, P...........New York, N. Y.
Davey, W.........Jersey City, N. J.
David, E. V.........New York, N. Y.
David, M. S...........Boston, Mass.
Davidson, A...........Boston, Mass.
Davidson, C. L......New York, N. Y.
Davidson, E. H........Hillside, N. J.
Davidson, E. T.......Brooklyn, N. Y.
Davidson, H. H......Brooklyn, N. Y.
Davidson, H. O.........Meadville, Pa.
Davidson, J. C.Prince Bay, S. I., N. Y.
Davidson, K. S. M.....Hoboken, N. J.
Davidson, M. W....Vermillion, S. D.
Davidson, R. R.......Maryville, Tenn.
Davidson, W. A.....New York, N. Y.
Davidson, W. F.......Brooklyn, N. Y.
Davidson, Wm. H......Girard, Ohio
Davidson, Wm. Harold..Trujillo, D. R.
Davies, A. W......Glasgow, Scotland
Davies, C. A..........Dayton, Ohio
Davies, C. E........New York, N. Y.
Davies, T. H.......Jersey City, N. J.
Daviet, C. E.............Larose, La.
Davis, A. B........Middletown, Ohio
Davis, Arthur Chas..New Orleans, La.
Davis, Arthur Clayton..Denver, Colo.
Davis, Arthur Councilman.......
New York, N. Y.
Davis, A. L........Waterbury, Conn.
Davis, C. A., Jr..........Peoria, Ill
Davis, C. B..........Birmingham, Ala.
Davis, C. E............Darien, Conn.
Davis, C. H.........Bass River, Mass.
Davis, C. L......Santa Monica, Calif.
Davis, C. R......Toronto, Ont., Can.
Davis, D. E..........Newark, N. J.
Davis, E. A.........E. Pittsburgh, Pa.
Davis, E. C......Sparrows Point, Md.
Davis, E. F.......Schenectady, N. Y.
Davis, E. L............Chicago, Ill.
Davis, E. W...........St. Louis, Mo.
Davis, F. C.......Newport News, Va.
Davis, Frank Lawrence..Aldene, N. J.
Davis, Franklin L......Portland, Ore.
Davis, F. P........Providence, R. I.
Davis, F. R...............Bath, Me.
Davis, G. H........New York, N. Y.
Davis, G. M............Richmond, Va.
Davis, H. N.........Hoboken, N. J.
Davis, H. R..............Chicago, Ill.
Davis, H. S..............Chicago, Ill.

Davis, J. D.........Pittsburgh, Pa.
Davis, J. H..........Potsdam, N. Y.
Davis, L. E.......Los Angeles, Calif.
Davis, L. F.........Longview, Tex.
Davis, N. L.....E. Weymouth, Mass.
Davis, O. A..........Alliance, Ohio
Davis, R. G...........Chicago, Ill.
Davis, R. W.......New York, N. Y.
Davis, W. J., Jr...Schenectady, N. Y.
Davol, F. H., Jr.....Stamford, Conn.
Davy, A. H..........Brooklyn, N. Y.
Dawes, H. N......Winchester, Mass.
Dawes, R..........Philadelphia, Pa.
Dawley, C. A.......Plainfield, N. J.
Dawson, A..........Cleveland, Ohio
Dawson, C. W..........Taft, Calif.
Dawson, P. B., Jr....Berkeley, Calif.
Day, A. V........E. Hartford, Conn.
Day, Chas. Corson........Vail, Ariz.
Day, Colin C........Stockport, Eng.
Day, C. I...............Troy, N. Y.
Day, C. M...........Denver, Colo.
Day, E. T..........Providence, R. I.
Day, H. L...........Stamford, Conn.
Day, J. A........Schenectady, N. Y.
Day, R. A..........Providence, R. I.
Day, R. B............Cleveland, Ohio
Day, R. R...........Cincinnati, Ohio
Daykin, I. H........Cleveland, Ohio
Dayton, F...........Pueblo, Colo.
Dayton, J. T.......Bremerton, Wash.
Deacon, A. P....Ingersoll, Ont., Can.
Deady, H. E.....Johnson City, Tenn.
Deakin, H..........New York, N. Y.
Deale, R. C.....Babylon, L. I., N. Y.
Dean, D. K........New York, N. Y.
Dean, E. S............London, Eng.
Dean, E. W......Battle Creek, Mich.
Dean, F. E...........Hillside, N. J.
Dean, F. F.........Kingsport, Tenn.
Dean, F. H.........Philadelphia, Pa.
Dean, F. W............Boston, Mass.
Dean, H..............Detroit, Mich.
Dean, H. C...Long Island City, N. Y.
Dean, H. K...........Boston, Mass.
Dean, R. R.............Tulsa, Okla.
Dean, S.................Toledo, Ohio
Dearasaugh, J. P.....Cleveland, Ohio
Dearborn, W. L......Sandwich, Mass.
Dearing, E. R.......Birmingham, Ala.
de Arozarena, R. M..Address Unknown
De Baufre, W. L.......Lincoln, Neb.
de Bethune, G. S. P..New York, N. Y.
DeBlois, L. A......New York, N. Y.
DeBoo, J. H............Chicago, Ill.
De Bruin, E. A...Cedar Rapids, Iowa
deBruyn, P. R....E. Hartford, Conn.
Debski, T. F.......New York, N. Y.
de Cazenove, L. A., Jr.........
Theological Seminary, Va.
De Cenzo, E. P.......Detroit, Mich.
Dechant, F. H.........Reading, Pa.
Deckard, R. H.........Lancaster, Pa.
Decker, C. A..........Clifton, N. J.
Decker, H. A......Rochester, N. Y.
Decker, H. L...........Altoona, Pa.
Decker, J.........Collingswood, N. J.
de Coriolis, E. G........Toledo, Ohio
De Crecy, J.........New York, N. Y.
Dedrick, F. F........Brooklyn, N. Y.
Dee, W. V........Coral Gables, Fla.
Deeds, E. A........New York, N. Y.
Deegan, W............Newark, Ohio
Deering, E. E.....Bridgeport, Conn.
DeGhardt, T. R......Hammond, Ind.
de Florez, L.......New York, N. Y.
DeFoe, J. C...........Augusta, Kan.
DeForest, C. W.....Cincinnati, Ohio
De Forest, E. T.......Newark, N. J.
de Fremery, D....Los Angeles, Calif.
de Fréminville, C.......Paris, France
Degen, J. W........New York, N. Y.
Degener, G. O..San Francisco, Calif.
Degler, H. E............Austin, Tex.
de Goirigolzarri, M.....Havana, Cuba
DeHamer, J. R.....Kalamazoo, Mich.
DeHuff, H..........Philadelphia, Pa.
Deily, A. T...........Pittsburgh, Pa.
Deimel, R. F.........Hoboken, N. J.
de Jony, T.........Philadelphia, Pa.
DeJuhasz, K. J.....State College, Pa.
DeKeyser, J. F.Long Island City, N. Y.
Delano, R. P., Jr.....Baltimore, Md.
Delany, C. H...San Francisco, Calif.
de Lapotterie, H.........Kent, Ohio
de la Torre, L. G....Bloomfield, N. J.
Delaune, H. L........Destrehan, La.
De Leeuw, A. L......Plainfield, N. J.
del Fungo-Giera, P.............
Mongaup Valley, N. Y.
Delgrosso, G.........Hamilton, Ohio
Dell, E. R.........Philadelphia, Pa.
Dell, W. H.........Philadelphia, Pa.
Dellplain, M........Philadelphia, Pa.
de Lorenzi, O.......New York, N. Y.
del Paso, A...........Mexico, Mex.
DeLuca, Ernest........Boulder, Colo.

De Luca, Everett.......Parlin, N. J.
De Marco, R. P......New York, N. Y.
Demarest, H. S.....New York, N. Y.
de Mauriac, W. J...Philadelphia, Pa.
De May, J. A..........Barberton, Ohio
Demchak, A. P......Cleveland, Ohio
Deming, A. K..........Dayton, Ohio
Demorest, G. E........Flint, Mich.
Demougeot, G. M............
New Brunswick, N. J.
Dempsey, M. J.....Waterbury, Conn.
Denari, E. J.........Brooklyn, N. Y.
Den Hartog, J. P...............
Wellesley Hills, Mass.
Denig, F...........Pittsburgh, Pa.
Denison, G.........New York, N. Y.
Denley, A. N..........Boston, Mass.
Denman, B. J...........Chicago, Ill.
Dennen, W. B.......Worcester, Mass.
Denninger, E.......New York, N. Y.
Dennis, B. W.... ....Baltimore, Md.
Dennison, E. S.........Groton, Conn.
Denniston, J. B.....Cincinnati, Ohio
Densen, D. A........Elmsford, N. Y.
Dent, J. A..........Pittsburgh, Pa.
Denton, A. P.......New York, N. Y.
Denton, L. I....San Francisco, Calif.
Dentraygues, J...San Francisco, Calif.
Depairon, J.Niagara Falls, Ont., Can.
Deppeler, J. H.......New York, N. Y.
de Queiroz, J. A...............
Recife, Pernambuco, S. A.
Derby, M. R...........Chicago, Ill.
DeRemer, J. G......New York, N. Y.
De-Rentiis, A.....Prospect Park, Pa.
Deringer, B. W., Jr..Baltimore, Md.
DeRonde, L. A......New York, N. Y.
DeRoo, W. C..........Kokomo, Ind.
Derr, T. S............Waban, Mass.
Derrick, A. E.......New York, N. Y.
Derry, G. C...........Boston, Mass.
deSchweinitz, P. B....Bethlehem, Pa.
De Smaele, A......Brussels, Belgium
De Somma, A.........Brooklyn, N. Y.
Destin, P. T.....San Francisco, Calif.
Dettloff, A. M......New York, N. Y.
Deutsch, Z. G..........Saltville, Va.
Deutchman, J.........Yonkers, N. Y.
Deutschman, M..........Easton, Pa.
deVarona-Agüero, P..Camaguey, Cuba
De Vau, L. P........Cleveland, Ohio
Deverall, C. N.......Buffalo, N. Y.
Devereux, H. M.....New York, N. Y.
DeVisser, J. H........Detroit, Mich.
Devlin, E. J..........Brooklyn, N. Y.
Devlin, L. J., Jr....Inglewood, Calif.
DeVoe, J............Madison, Tenn.
Devoy, E. B.........Honolulu, T. H.
DeVries, R. P.........Boston, Mass.
Dew, D. H.........Canastota, N. Y.
Dew, P. H........Washington, D. C.
Dewees, N. B......San Gabriel, Calif.
Dewell, C. J..........Windsor, Vt.
Dewey, F. S........Cincinnati, Ohio
Dewey, W. V...........Chicago, Ill.
Dewling, L. E.......Petersburg, Va.
DeWolf, P. C........Providence, R. I.
DeWolf, R. D.......Rochester, N. Y.
DeWolfe, E. C..........Chicago, Ill.
Dewson, E. H........Davenport, Fla.
Dexter, A. J....Chicopee Falls, Mass.
Dexter, B. P..........Orange, Mass.
Dexter, C. F.........Norwood, Mass.
Dexter, G. M.......Scarsdale, N. Y.
Dexter, H. E....Poughkeepsie, N. Y.
Dexter, H. W., Jr....Pittsburgh, Pa.
de Zafra, C.........New York, N. Y.
Dhar, M.............Calcutta, India
DiAddario, A. N.......Buffalo, N. Y.
Diamant, S...........Newark, N. J.
Diaz, E. ....
Buenos Aires, Argentina, S. A.
Diaz-Compain, J.......Senado, Cuba
Dibblee, H. J.......Schnecksville, Pa.
Dibert, H. M............Troy, N. Y.
Dick, A. C..........Elizabeth, N. J.
Dickerman, A. C.....Providence, R. I.
Dickerman, W. C.....New York, N. Y.
Dickerson, H. S.......Columbus, Ohio
Dickerson, K. J.....W. Lynn, Mass.
Dickerson, T. C., Jr...........
Newport News, Va.
Dickey, A. J.....Toronto, Ont., Can.
Dickey, D. E..........St. Louis, Mo.
Dickey, P. S.........Cleveland, Ohio
Dickey, S. J......Los Angeles, Calif.
Dickie, A. J....San Francisco, Calif.
Dickinson, E. D......W. Lynn, Mass.
Dickinson, G. S......New York, N. Y.
Dickinson, H. C...Washington, D. C.
Dickinson, M. H......Windsor, Conn.
Dickinson, R. W...Los Angeles, Calif.
Dickinson, W. N...............
Rockville Center, L. I., N. Y.
Dickson, O. H.......New York, N. Y.
Dickson, John........Portland, Ore.
Dickson, John.......Swarthmore, Pa.

Dickson, J. F.........Kewanee, Ill.
Didriksen, H......Bound Brook, N. J.
Dieckmann, O. A.....Goldpoint, Nev.
Diederichs, H..........Ithaca, N. Y.
Diedrich, W. C........St. Louis, Mo.
Diedrichs, G. C................
Buenos Aires, Argentina, S. A.
Diefenbach, J. S......Shelton, Conn.
Diefendorf, D. W.....Syracuse, N. Y.
Dieffenbach, E. C....Yonkers, N. Y.
Diehl, A. N....San Francisco, Calif.
Diekmann, H. A...............
Richmond Hill, L. I., N. Y.
Diemer, H.............Chicago, Ill.
Dierckx, J..........New York, N. Y.
Dierdorf, C. C............Gary, Ind.
Diescher, A. P......Pittsburgh, Pa.
Diescher, S. E.......Pittsburgh, Pa.
Dieter, W............Newark, N. J.
Dieterichs, F. F.....Philadelphia, Pa.
Dietrich, A. G.....New York, N. Y.
Dietrich, C. D.....Granite City, Ill.
Dietrichson, W. F.......Berwick, Pa.
Dietz, C. F.........New York, N. Y.
Dietz, F. M..........Trenton, N. J.
Dievers, G. E.......Philadelphia, Pa.
Diffendal, J. J......McKeesport, Pa.
DiGiovanni, M........Newark, N. J.
Dignan, G. E..........Carnegie, Pa.
Dilcher, H. S....Huntington, W. Va.
Dilg, W. C...........Hewlett, N. Y.
Dill, A. H............Dover, N. J.
Dillard, J. B.........Cleveland, Ohio
Dillman, H. F.........Altoona, Pa.
Dillon, E. L..........St. Louis, Mo.
Dillon, F. H..........Malden, Mass.
Dillon, H. J.......Waterbury, Conn.
Dillon, J. H...........Chicago, Ill.
Dillon, J. J.....Montreal, Que., Can.
Dillon, S.............Pittsburgh, Pa.
Dimberg, P. C.........W. Allis, Wis.
Dimmick, H. S......Philadelphia, Pa.
D'Imor, E. J..........St. Joseph, Mo.
Di Nardo, H. W.....Philadelphia, Pa.
Dinger, H. C.......New York, N. Y.
Director, I.........Philadelphia, Pa.
Dirks, H. B.........E. Lansing, Mich.
Dirksen, P. C., Jr.New Bedford, Mass.
Di Santo, B. J.........Maurer, N. J.
Dise, L. R...........Harrison, N. J.
Diserens, P.........Harrison, N. J.
Dishington, H.......Pittsburg, Calif.
Disston, W. D......Philadelphia, Pa.
Distel, R. E..........Lansing, Mich.
Ditmars, W. E.....New York, N. Y.
Dival, L. A...........Atchison, Kan.
Divan, L. S........Philadelphia, Pa.
Diver, M. L......San Antonio, Tex.
Dixon, C. F.......Philadelphia, Pa.
Dixon, J. J........Ann Arbor, Mich.
Dixon, L. S............Bangor, Me.
Dixon, S..............Auburn, Ala.
Dmitrieff, B. A......New York, N. Y.
Doan, T. H.........Cleveland, Ohio
Dobbins, G. S., Jr.....Boulder, Colo.
Doble, W. A....San Francisco, Calif.
Dobrogowski, R. A...Milwaukee, Wis.
Dobson, J..........Brooklyn, N. Y.
Dobson, J. G..........Clinton, N. J.
Dobyne, S. A.........St. Louis, Mo.
Dockstader, E. K....New York, N. Y.
Dodd, J. A.............Atlanta, Ga.
Dodge, Albert Cole..New York, N. Y.
Dodge, Arthur Chas.....Chicago, Ill.
Dodge, G. F..........Columbus, Ohio
Dodge, K..........Philadelphia, Pa.
Dodson, C. R.........La Habra, Calif.
Dodson, R. W........E. St. Louis, Ill.
Doelling, H. A.Mountain Lakes, N. J.
Doering, W. C........St. Louis, Mo.
Doggett, J., Jr.......Houston, Tex.
Doherty, H. L.....New York, N. Y.
Dohrmann, H. C.........Warren, Pa.
Doig, G. D.........New York, N. Y.
Doke, G. E...........Oak Park, Ill.
Dolan, C. H., II.....New York, N. Y.
Dolan, T. J.............Urbana, Ill.
Dole, M. W..........Belmont, Mass.
Dolesh, F. J...........Chicago, Ill.
Dolezal, E.........Bartlesville, Okla.
Doll, C. J............Newark, N. J.
Dollar, W. M..........Buffalo, N. Y.
Dolumbal, T. A.....Mambajao, P. I.
Dolve, R. M.............Fargo, N. D.
Domaige, G. L. J...Providence, R. I.
Domantay, F. J.........Chicago, Ill.
Dominguez, C. E....New York, N. Y.
Domonoske, A. B.............
Stanford Univ., Calif.
Don, J. M...........St. Louis, Mo.
Donahue, P........Philadelphia, Pa.
Donald, W. J.......New York, N. Y.
Donaldson, C.......Rochester, N. Y.
Donnell, L. H...........Akron, Ohio
Donnelly, J. A.......Largent, W. Va.
Donnelly, J. B......Philadelphia, Pa.
Donnelly, M. A.....Upper Darby, Pa.

Donohoe, C. F........Detroit, Mich.
Donovan, D. E....Sparrows Point, Md.
Donovan, E. L......New York, N. Y.
Donovan, E. T........Durham, N. H.
Doolin, E..........Washington, D. C.
Doolittle, H. L....Los Angeles, Calif.
Doolittle, J. H........St. Louis, Mo.
Doolittle, W. P.....Waterbury, Conn.
Dopp, C. A............Chicago, Ill.
Doppel, L..........New York, N. Y.
Doran, C. S..................
Rockville Center, L. I., N. Y.
Dorbandt, F. C..........York, Pa.
Doré, A. J.............Chicago, Ill.
Doremus, G. A......Brooklyn, N. Y.
Dorer, O. H........Harrison, N. J.
Dorfan, M. I.........Pittsburgh, Pa.
Doriot, G. F..........Boston, Mass.
Dorman, N. W..........Toledo, Ohio
Dorman, W. W...Grand Rapids, Mich.
Dorn, R. W.....Los Angeles, Calif.
Dornbirer, W. M.....Columbus, Ohio
Dornbrook, F. L.....Milwaukee, Wis.
Dorner, F. H........Milwaukee, Wis.
Doroff, S. W..........Chelsea, Mass.
Dorschel, L. J......Milwaukee, Wis.
Dorsey, F. E........Hartford, Conn.
Dorsey, G. P.........Seattle, Wash.
Dorward, J. L.......Rahway, N. J.
Dotson, C. C............Gary, Ind.
Doty, P.............St. Paul, Minn.
Dougherty, C. J..........Miami, Fla.
Dougherty, W. F., Jr.New York, N. Y.
Doughtie, C. E., Jr.....Atlanta, Ga.
Doughtie, V. L........Lubbock, Tex.
Doughty, W. F......New York, N. Y.
Douglas, D. C......Ann Arbor, Mich.
Douglas, F. S..........Augusta, Ga.
Douglas, G. M......Clarkdale, Ariz.
Douglas, J......Edinburgh, Scotland
Douglas, J. R........Coventry, Eng.
Douglas, L. L.......Brooklyn, N. Y.
Douglass, A. E......Catasauqua, Pa.
Douglass, M. E...Schenectady, N. Y.
Douthit, J. H....New London, N. C.
Dow, A..............Detroit, Mich.
Dow, G. L............Detroit, Mich.
Dow, H. W.........Milwaukee, Wis.
Dow, R. F..........Hartford, Conn.
Dowd, B. J..........Hartford, Conn.
Dowd, S. B.........Worcester, Mass.
Dowdell, S. H....Toronto, Ont., Can.
Dowding, L. E.........Boston, Mass.
Dowell, D.........Philadelphia, Pa.
Dowler, E. A.....Toronto, Ont., Can.
Dowling, D. L......New York, N. Y.
Dowling, E. D., Jr...New York, N. Y.
Downe, E. R.......New York, N. Y.
Downe, H. S...........Paris, France
Downes, N. W......Kansas City, Mo.
Downey, W. W......New York, N. Y.
Downie, J. S...................
Corner Brook, Newfoundland
Downing, B. H.....Greenwich, Conn.
Downing, D. G......Worcester, Mass.
Downing, H. F...Portsmouth, N. H.
Downing, J. C........Buffalo, N. Y.
Downs, C. R.......New York, N. Y.
Downs, E. S..........Newark, N. J.
Downs, J. N.........Barberton, Ohio
Downs, J. W......Los Angeles, Calif.
Downs, L. B..........Oil City, Pa.
Downs, S. H.......Kalamazoo, Mich.
Dows, H. W........Worcester, Mass.
Dows, S. R......San Francisco, Calif.
Dowson, H. R...........Easton, Pa.
Doyle, E. D........Philadelphia, Pa.
Doyle, W. L. H......Swarthmore, Pa.
Drabelle, J. M....Cedar Rapids, Iowa
Drake, C. M..........Detroit, Mich.
Drake, R. W......Indianapolis, Ind.
Drake, W. A...........Dayton, Ohio
Drake, W. C........New York, N. Y.
Drake, W. V......Fairmont, W. Va.
Dralle, W. F.......Philadelphia, Pa.
Draper, C. S........Cambridge, Mass.
Dreffein, H. A.........Chicago, Ill.
Dresden, D......Utrecht, Netherlands
Drew, W. E..........Jacksonville, Fla.
Drewett, W. A.....Providence, R. I.
Drewry, M. K.......Milwaukee, Wis.
Drewry, T. W.....Newport News, Va.
Dreyer, E. J.........Louisville, Ky.
Dreyer, E. L......Wilmington, Calif.
Dreyfus, E. D.......Pittsburgh, Pa.
Driscoll, J. M.......Brooklyn, N. Y.
Driver, A..............Findlay, Ohio
Drobile, A. W......Philadelphia, Pa.
Drogue, J. A.......Noblesville, Ind.
Drucker, A............Chicago, Ill.
Drum, L. J., Jr.........Atlanta, Ga.
Drummond, A. S....Pt. Huron, Mich.
Drummond, G. B.....Memphis, Tenn.
Drummond, W. C.......Chicago, Ill.
Drutman, J.........Brooklyn, N. Y.
Drutzu, S. T.......New York, N. Y.

Dryden, H. L......Washington, D. C.
Dryer, E. L...........Lancaster, Pa.
Drypolcher, W.....New York, N. Y.
Drysdale, W. D........Detroit, Mich.
DuboscIard, P.........Buffalo, N. Y.
DuBosque, F. L..........Miami, Fla.
DuBrul, E. F.......Cincinnati, Ohio
Du Chateau, M. F., Jr...Chicago, Ill.
Duchnowski, H. E......Passaic, N. J.
Ducker, W. L...........Tulsa, Okla.
Duckett, E. J.......Cullowhee, N. C.
Du Comb, W. C.......Detroit, Mich.
Ducommun, E......Rutherford, N. J.
Duda, O.............Corsicana, Tex.
Dudley, E. F...........Chicago, Ill.
Dudley, S. W......New Haven, Conn.
Dudley, W. L.........Seattle, Wash.
Dudley, W. M.........Cleveland, Ohio
Duensing, H. F. A............
Blankenese-Elbe, Germany
Duffey, P. R..........Buffalo, N. Y.
Duffy, T. J............Boston, Mass.
Dugger, N.........Birmingham, Ala.
Dull, R. W............Chicago, Ill.
DuMoulin, W. L..........Ajo, Ariz.
Dun, H. W., Jr......New York, N. Y.
Dunagan, A...........Portland, Ore.
Dunagan, S. V........Detroit, Mich.
Dunbar, A. W.....High Point, N. C.
Dunbar, J. H........Cleveland, Ohio
Duncan, C. A......Fairmont, W. Va.
Duncan, D. S........Brooklyn, N. Y.
Duncan, G. W.....Los Angeles, Calif.
Duncan, J. C......New York, N. Y.
Duncan, J. M.........Hopewell, Va.
Duncan, J. R.......New York, N. Y.
Duncan, S. F.....Los Angeles, Calif.
Duncan, W. M............Alton, Ill.
Duncan, W. Y., Jr..New Haven, Conn.
Dundore, M. W..........Beloit, Wis.
Dundore, R. D......New York, N. Y.
Dunford, G. S.....Chambersburg, Pa.
Dungan, D. K......San Carlos, Calif.
Dungan, E. R......Rochester, N. Y.
Dunham, B. W........Oakmont, Pa.
Duham, W. E.........Glen Ellyn, Ill.
Dunigan, E. B..........Chicago, Ill.
Dunkin, W. V...........Atlanta, Ga.
Dunkle, H. E.........Richmond, Va.
Dunlap, R. T....San Francisco, Calif.
Dunlop, C. W.....New Haven, Conn.
Dunlop, W. C.......New York, N. Y.
Dunn, E. L.........New York, N. Y.
Dunn, G...........New York, N. Y.
Dunn, J. Jay........Pittsburgh, Pa.
Dunn, Jas. Jay...........Large, Pa.
Dunn, J. W...........Newark, N. J.
Dunn, S. M......Los Angeles, Calif.
Dunn, W. R.......Philadelphia, Pa.
Dunnell, W. W., Jr.....Boston, Mass.
Dunnican, G. W.....Bloomfield, N. J.
Dunning, H.........New York, N. Y.
Dunsford, J. R...........Tiffin, Ohio
Duntze, J. A.........Norwalk, Conn.
Dupee, C. F.......Springfield, Mass.
Dupont, A. T......Washington, D. C.
Dupont, L. C...........Houma, La.
Du Priest, J. R...Minneapolis, Minn.
Duram, A. E.........Springfield, Ill.
Durand, N. C.........Orange, N. J.
Durand, W. F...Stanford Univ., Calif.
Durant, A.........Cambridge, Mass.
Durban, T. E..............Erie, Pa.
Durbeck, A. C...Poughkeepsie, N. Y.
Durbin, P. C.......New York, N. Y.
Durgin, C. M..........Boston, Mass.
Durham, E.........New York, N. Y.
Durham, J. E., Jr.....Allentown, Pa.
Durkee, C. H.......New York, N. Y.
Durlach, M. R., Jr....Brooklyn, N. Y.
Durland, H. S.........Newark, N. J.
Durland, M. A......Manhattan, Kan.
Durland, W. P.......E. Orange, N. J.
Durley, R. J.....Montreal, Que., Can.
Durrstein, V. L.......Columbus, Ind.
Dursin, H., Jr.....Woonsocket, R. I.
Durward, E. S.........Houston, Tex.
Duryea, A. A.......New York, N. Y.
Dutcher, J. E..........Chicago, Ill.
Dutton, D.............Topeka, Kan.
Dutton, D. W.........St. Louis, Mo.
Dutton, F. O........New York, N. Y.
Dutton, H. P..........Evanston, Ill.
Dutton, M. K........Pittsburgh, Pa.
DuVillard, H. A....Providence, R. I.
Dvorak, C. J.....Hollis, L. I., N. Y.
Dvorak, G..........New York, N. Y.
Dvorak, J............Houston, Tex.
Dwight, R. W.........Auburn, Ind.
Dwyer, E...........Detroit, Mich.
Dwyer, E. J......Schenectady, N. Y.
Dwyer, J. J.........Brooklyn, N. Y.
Dwyer, P. F.........New York, N. Y.
Dye, I. W............Seattle, Wash.
Dyer, F. L...........Ventnor, N. J.
Dyer, H. F..........Glasgow, Mont.
Dyer, R. L...........Seattle, Wash.

Dyer, W. B........New York, N. Y.
Dyer, W. E. S......New York, N. Y.
Dysarz, C. E.........Detroit, Mich.

E

Eadie, J. G.........New York, N. Y.
Eager, W. G...........Valdosta, Ga.
Eames, J. J.........Cambridge, Mass.
Earhart, A..........New York, N. Y.
Earl, R............New Orleans, La.
Earle, R...........Worcester, Mass.
Earle, S. B....Clemson College, S. C.
Earll, C. I..............York, Pa.
Eason, C. M.........Waukesha, Wis.
Eason, J. J............Trona, Calif.
East, F. G.......Toronto, Ont., Can.
East, L. H.........Rochester, N. Y.
East, W. E............Chicago, Ill.
Eastling, H. V...San Francisco, Calif.
Eastman, C. A......New York, N. Y.
Eastman, F. C..........Beverly, Mass.
Easton, E., Jr....New Rochelle, N. Y.
Easton, W. M.................
Shawinigan Falls, Que., Can.
Eastwood, E. O.......Seattle, Wash.
Eaton, C. L..........Lynchburg, Va.
Eaton, F. L., Jr.....Worcester, Mass.
Eaton, G. C...........Boston, Mass.
Eaton, G. H......New Haven, Conn.
Eaton, G. M......Los Angeles, Calif.
Eaton, H. N......Washington, D. C.
Eaton, J. F............Tulsa, Okla.
Eaton, L. S............Manila, P. I.
Eaton, P. B.............Easton, Pa.
Eaton, W..............Chicago, Ill.
Eaton, W. S..Sag Harbor, L. I., N. Y.
Eaton, W. W...........Canton, Ohio
Ebaugh, N. C.......Gainesville, Fla.
Ebel, R. A...........Brooklyn, N. Y.
Ebel, W. J.........New York, N. Y.
Eberhardt, F. E......S. Orange, N. J.
Eberhardt, F. L.....Irvington, N. J.
Eberhardt, H. E......Irvington, N. J.
Eberhardt, J. D.......Lisbon, N. H.
Eberhardt, U. S....Maplewood, N. J.
Eberle, F. H.........Rahway, N. J.
Eberly, C. M....Salt Lake City, Utah
Ebert, J. W., Jr.......Hampton, Va.
Eblen, W. F........Harlingen, Tex.
Ebner, A. J...........Chicago, Ill.
Eby, E. E..........New York, N. Y.
Eccleston, R. C........Ridgway, Pa.
Eck, A. E...........Harrisburg, Pa.
Eckart, W. R.......Alhambra, Calif.
Eckert, A. C.........St. Louis, Mo.
Eckert, H. R......Jersey City, N. J.
Eckert, J. S...........Ottawa, Ohio
Eckert, O. E..........Lansing, Mich.
Eckhard, W. K.......Westerly, R. I.
Eckhardt, C. J., Jr.....Austin, Tex.
Eckhardt, F. S...Lackawanna, N. Y.
Eckstrom, A. W.......Buffalo, N. Y.
Eddison, W. Barton............
Ardsley-on-Hudson, N. Y.
Eddy, H. P., Jr.......Boston, Mass.
Eddy, H. S...........Harrison, N. J.
Eddy, J. H.............Lynn, Mass.
Eddy, W. T.........Brooklyn, N. Y.
Edel, W. L............Storrs, Conn.
Edelstein, A........New York, N. Y.
Eden, F. L............Leonia, N. J.
Eder, J. P....Forest Hills, L. I., N. Y.
Ederer, L. A...........Chicago, Ill.
Edgerton, L. B....Philadelphia, Pa.
Edis, M. A..........Brooklyn, N. Y.
Edmands, S. S.........Brooklyn, N. Y.
Edmiston, M. O.....Kansas City, Mo.
Edmonds, R. H. G....Seattle, Wash.
Edmondson, W. G....Elizabeth, N. J.
Edmunds, L. L..........Ross, Calif.
Edwards, A.........Bridgeport, Conn.
Edwards, A. B...Los Angeles, Calif.
Edwards, C. L........Hopewell, Va.
Edwards, E. D...........Peoria, Ill.
Edwards, G. M......Brooklyn, N. Y.
Edwards, H. B......Rochester, N. Y.
Edwards, H. D......New York, N. Y.
Edwards, Henry Hartley........
Jersey City, N. J.
Edwards, Henry Harmon.......
Bristol, Conn.
Edwards, J. B........Detroit, Mich.
Edwards, L. V..................
Rockville Center, L. I., N. Y.
Edwards, T. W....Charlottesville, Va.
Edwards, W. H.....New York, N. Y.
Edwards, W. W.......Boston, Mass.
Eeles, C. C............Toledo, Ohio
Effross, M. P.......New York, N. Y.
Egan, B. E...........Compton, Calif.
Egan, H. J.........Waterbury, Conn.
Egan, K. W.......Schenectady, N. Y.
Egbert, C. C....Niagara Falls, N. Y.
Eggert, E. H.........Baltimore, Md.

Eggleston, H. L....Los Angeles, Calif.
Egilsrud, F. S.......Brooklyn, N. Y.
Egleston, M. P........Garfield, Utah
Egleston, O. J...Salt Lake City, Utah
Egloff, F.............Riverside, Ill.
Ehbrecht, A........New York, N. Y.
Ehlers, H. E........Philadelphia, Pa.
Ehrenburg, H. H..............
Hengelo, Netherlands
Ehrhardt, J. J.....Jersey City, N. J.
Ehrhart, G. W...........Watson, Calif.
Ehrhart, R. N.........Ventnor, N. J.
Ehrke, L. F.........Bloomfield, N. J.
Ehrlich, B..........Brooklyn, N. Y.
Ehrlich, M. W......Lyndhurst, N. J.
Eibsen, L. J........New York, N. Y.
Eichelsbach, G., Jr.....St. Louis, Mo.
Eichin, H. P...........Chicago, Ill.
Eichler, A. J.......New York, N. Y.
Eidmann, F. L......New York, N. Y.
Eigenbrot, J. L.....Philadelphia, Pa.
Eilersgaard, A.....Los Angeles, Calif.
Einbeck, A. C., Jr...Grantwood, N. J.
Einfeldt, C. L.........Detroit, Mich.
Einig, A. B..........Cleveland, Ohio
Einstein, S.........Cincinnati, Ohio
Eisele, P. T..........Cleveland, Ohio
Eisenbrey, R. H....Philadelphia, Pa.
Eiserman, F. J.....Pearl River, N. Y.
Eisler, C.............Newark, N. J.
Eister, W. D.........Ft. Belvoir, Va.
Ek, A.................Murray, Utah
Ek, G. C.............Denver, Colo.
Ekegren, O J.......Woodcliffe, N. J.
Eklind, C. E............Chicago, Ill.
Eklund, J.......New Rochelle, N. Y.
Eklund, K. F.Jefferson Barracks, Mo.
Eksergian, C. L.......Detroit, Mich.
Eksergian, R.......Philadelphia, Pa.
Ekstrom, C. W..........Moline, Ill.
Elam, E. W......Whitehaven, Tenn.
Eland, F. H.....Toronto, Ont., Can.
Elberson, L. P.........Crowley, La.
Elder, A. M.........Great Bend, Kan.
Elder, J. D..........Baltimore, Md.
Eldert, J. D........Providence, R. I.
Eldred, B. E.......New York, N. Y.
Eldredge, A. H.........Boston, Mass.
Eldridge, F. G......Newburgh, N. Y.
Eldridge, G. B..........Akron, Ohio
Eley, R. V............Detroit, Mich.
Elfring, J. B........Cincinnati, Ohio
Elizardi, F. P...........Dallas, Tex.
Elkus, J. H..........Pittsburgh, Pa.
Ell, C. S..............Boston, Mass.
Ellenberger, W. J..Washington, D. C.
Ellenwood, F. O.........Ithaca, N. Y.
Ellicott, C. R......New York, N. Y.
Ellingwood, E. L..Los Angeles, Calif.
Elliot, A. H..........New York, N. Y.
Elliott, B. G..........Madison, Wis.
Elliott, E...........Worcester, Mass.
Elliott, E., Jr....Schenectady, N. Y.
Elliott, E. G.....Los Angeles, Calif.
Elliott, G. F.........Pittsburgh, Pa.
Elliott, H. F.........Cleveland, Ohio
Elliott, J. S.......Port Arthur, Tex.
Elliott, L..........New York, N. Y.
Elliott, N. R..........Portland, Me.
Elliott, R. B.........Galt, Ont., Can.
Elliott, R. F.......New York, N. Y.
Elliott, W., Jr......Paterson, N. J.
Ellis, A. L........Waterbury, Conn.
Ellis, C. A........New York, N. Y.
Ellis, C. E...........Memphis, Tenn.
Ellis, D. M.........Washington, D. C.
Ellis, D. S...........Cleveland, Ohio
Ellis, F. A......Montreal, Que., Can.
Ellis, F. R............Boston, Mass.
Ellis, G. P..........Pittsburgh, Pa.
Ellis, J............Kingsport, Tenn.
Ellis, O. W.......Toronto, Ont., Can.
Ellis, W. T.........Blacksburg, Va.
Ellison, L. M...........Chicago, Ill.
Ellman, L...........Pittsburgh, Pa.
Ellson, H. S.........Saint Marys, Pa.
Elly, R. D..........Elizabeth, N. J.
Elmer, L. A.........New York, N. Y.
Elmer, N. W...........Chicago, Ill.
Elmer, W............Bay Head, N. J.
Elmes, C. W...........Chicago, Ill.
Elmore, O. R........Brooklyn, N. Y.
Elrod, H. E...........Houston, Tex.
Elsas, N. E.............Atlanta, Ga.
Elsas, W. R.............Atlanta, Ga.
Elsner, W. H.........St. Paul, Minn.
Elwell, F. D...........Flint, Mich.
Elwell, R. D........Brooklyn, N. Y.
Elwood, C. A...........Chicago, Ill.
Ely, A. J...........Elizabeth, N. J.
Ely, E. W.........Washington, D. C.
Ely, S. B............Pittsburgh, Pa.
Emanuelsen, J........Detroit, Mich.
Embacher, H. R......Brooklyn, N. Y.
Emens, A. L...........Lafayette, Ind.
Emeny, F. J............Salem, Ohio
Emerson, C. L..........Atlanta, Ga.

Emerson, F. E......San Mateo, Calif.
Emerson, G. H.........Baltimore, Md.
Emerson, J. P.Long Island City, N. Y.
Emery, A. H........Stamford, Conn.
Emery, H........N. Arlington, N. J.
Emery, J. R............Toledo, Ohio
Emhardt, F. W..........Warren, Pa.
Emmet, H. LeR............Erie, Pa.
Emmet, W. LeR...Schenectady, N. Y.
Emmons, H. W.....Cambridge, Mass.
Emmons, N. A.........Summit, N. J.
Emory, J. B..........St. Louis, Mo.
Endicott, G.........Worcester, Mass.
Endicott, G. F.......St. Paul, Minn.
Endlich, W. H. G...New York, N. Y.
Endsley, Louis E.....Pittsburgh, Pa.
Endsley, Louis Eugene, Jr......
Beacon, N. Y.
Enes, J. T............Chicago, Ill.
Engblom, A..........Boras, Sweden
Engdahl, R.............Urbana, Ill.
Engel, C. R.........Piermont, N. Y.
Engel, L. G........New York, N. Y.
Engelhart, L. C......Rochester, N. Y.
Engelking, W. W......Superior, Wis.
Engelman, W. H.....Cleveland, Ohio
Engle, D. E............Akron, Ohio
Engle, M. D..........Boston, Mass.
English, E. F....San Francisco, Calif.
English, F. S.....New London, Conn.
English, P. H......New Haven, Conn.
English, W. M.......Lafayette, Ind.
Englund, J. E......Providence, R. I.
Engvall, H..........Trenton, N. J.
Ennis, H. V.........Paterson, N. J.
Ennis, J. B.........Paterson, N. J.
Ennis, W. D.........Hoboken, N. J.
Eno, W. S.........New York, N. Y.
Ensinger, W. B....Washington, D. C.
Enz, K. A............Tokyo, Japan
Epley, F. I........New York, N. Y.
Epstean, E..........New York, N. Y.
Erb, E. M........W. Hartford, Conn.
Erdman, F. S..........Ithaca, N. Y.
Erickson, A....Salt Lake City, Utah
Erickson, A. C..........Chicago, Ill.
Erickson, A. L.....Los Angeles, Calif.
Erickson, E. A..........Chicago, Ill.
Erickson, E. G..........Moline, Ill.
Erickson, H. V.........Hopewell, Va.
Erickson, O. P..........Tampa, Fla.
Erickson, R............Chicago, Ill.
Erickson, R. E.......Cleveland, Ohio
Ericson, F. R.........W. Lynn, Mass.
Ermeling, L. B........Wilmette, Ill.
Ermenc, J. J......W. Lafayette, Ind.
Ernsberger, M. C.......Ithaca, N. Y.
Ernst, A. F........New York, N. Y.
Ernst, F. C.........New York, N. Y.
Ernst, H...........Cincinnati, Ohio
Ernst, W............Mt. Gilead, Ohio
Errington, F. A.Stapleton, S. I., N. Y.
Erskine, J. H.........Spencer, N. C.
Erskine, W. H....Minneapolis, Minn.
Ervin, T. C......Chattanooga, Tenn.
Erwin, H. P......Washington, D. C.
Esch, R. E...........Detroit, Mich.
Escher, W. F..............Peoria, Ill.
Eserkaln, T. F..........W. Allis, Wis.
Eshelman, C. M...Los Angeles, Calif.
Eshelman, J. W....Birmingham, Ala.
Esherick, G., Jr.....New York, N. Y.
Eskelund, A. A. K..Faaborg, Denmark
Eskin, B...........Harrison, N. J.
Eskin, S. G...........St. Louis, Mo.
Espig, E. E...........Buffalo, N. Y.
Espy, M. P..........Burlington, Vt.
Espy, W. N..............Urbana, Ill.
Esselstyn, H. H.......Detroit, Mich.
Essex, T. J.........Kansas City, Mo.
Essig, A. F.........Brooklyn, N. Y.
Essig, W..............Brooklyn, N. Y.
Estabrook, M........New York, N. Y.
Estcourt, V. F...San Francisco, Calif.
Estep, F. L........New York, N. Y.
Estep, T. G..........Pittsburgh, Pa.
Estergreen, H. M......Franklin, Pa.
Estes, W. W.......Providence, R. I.
Estrada, E. D..........Havana, Cuba
Estrada, R.............Havana, Cuba
Esty, F. B...........Unadilla, N. Y.
Etnyre, S. R..........Oregon, Ill.
Etter, L. F...........Topeka, Kan.
Euston, E........Washington, D. C.
Evans, C. O........New York, N. Y.
Evans, D. E..........Brisbane, Aust.
Evans, D. F.........Waynesboro, Va.
Evans, E. B.........Cincinnati, Ohio
Evans, E. R........New York, N. Y.
Evans, F. C.........New York, N. Y.
Evans, F. H.........Rochester, N. Y.
Evans, G. A..........Billings, Mont.
Evans, G. B.....Granite City, Ill.
Evans, G. D.............Norfolk, Va.
Evans, G. M...........Detroit, Mich.
Evans, H. J....Lyon Mountain, N. Y.
Evans, J..........New York, N. Y.
Evans, J. N.........Brooklyn, N. Y.
Evans, L. E...........St. Louis, Mo
Evans, L. R............Elmira, N. Y.
Evans, M. J............Chicago, Ill.
Evans, N. A..Garden City, L. I., N. Y.
Evans, R. T............Jokake, Ariz.
Evans, S..............Houston, Tex.
Evans, W. A......Maplewood, N. J.
Evans, W. F..........Detroit, Mich.
Evans, W. I............Chicago, Ill.
Evarts, H. M..........Buffalo, N. Y.
Evarts, R. E...........Chicago, Ill.
Everett, A..........New York, N. Y.
Everett, E. H.........Boston, Mass.
Everett, F. L......Ann Arbor, Mich.
Everett, H. A.....State College, Pa.
Everett, H. J.........Allentown, Pa.
Everett, H. L........Hoopeston, Ill.
Everett, R. W.......Cartaret, N. J.
Everett, W. S....San Francisco, Calif.
Evoy, M..............Abington, Pa.
Ewalt, N. C........New York, N. Y.
Ewart, A. F.........Honolulu, T. H.
Ewart, W. M..........St. Louis, Mo.
Ewen, R. L....Montego Bay, Jamaica
Ewens, F. G......Toronto, Ont., Can.
Ewer, R. G.........E. Orange, N. J.
Ewert, W. A...........Chicago, Ill.
Ewing, T. H.........Worcester, Mass.
Ewry, R. C...Douglaston, L. I., N. Y.
Exler, D. C.........Conowingo, Md.
Exley, G. R........Philadelphia, Pa.
Eyre, T. T........Los Angeles, Calif.

F

Faas, H..............Newark, N. J.
Faast, F...........Brooklyn, N. Y.
Fabel, D. C.........Cleveland, Ohio
Faber, A. F, Jr......Brooklyn, N. Y.
Faber, C. O..........Brooklyn, N. Y.
Faber, J. P.........Dunellen, N. J.
Faber, O..............Buffalo, N. Y.
Fabera, W...........Cincinnati, Ohio
Fabiroski, J. P......Brooklyn, N. Y.
Fahy, J. A.........New York, N. Y.
Faig, J. T..........Cincinnati, Ohio
Faile, E. H.........New York, N. Y.
Failmezger, E.........Syracuse, N. Y.
Failmezger, V. H......Buffalo, N. Y.
Fair, C............Portsmouth, Ohio
Fairbanks, C. M.....Swarthmore, Pa.
Fairbanks, F. L.....Wakefield, Mass.
Fairchild, F. P........Newark, N. J.
Fairchild, S. M......New York, N. Y.
Fairclough, H.........Midland, Mich.
Faires, V. M......College Sta., Tex.
Fairfield, H. P......Worcester, Mass.
Fairfield, J. G...........Troy, N. Y.
Fairfield, W. M...New Britain, Conn.
Fairman, S.........W. Lafayette, Ind.
Fairman, S. W.......Corning, N. Y.
Falconer, D. J...Sudbury, Ont., Can.
Fales, H. G.........New York, N. Y.
Fales, H. H........Providence, R. I.
Falian, C. L..Rottach-Egern, Germany
Falk, G. E..........Hartford, Conn.
Falk, H. S..........Milwaukee, Wis.
Falk, M. L.........Springfield, Colo.
Falkner, J. C.......New York, N. Y.
Falla, F...........New York, N. Y.
Fallon, D. G.......New York, N. Y.
Fallon, J...........Smethwick, Eng.
Fallon, J. H............Flint, Mich.
Falls, E. K........Cleveland, Ohio
Famiglietti, A. A.....Newark, N. J.
Fangemann, W. H....Brooklyn, N. Y.
Fanjul, H. C...........Havana, Cuba
Fankboner, H..........Chicago, Ill.
Fannon, W. A........Appleton, Wis.
Farbar, L........San Francisco, Calif.
Fardelmann, J. H., Jr.........
New York, N. Y.
Farley, E. W.........Richmond, Va.
Farmer, E. H..........Toledo, Ohio
Farmer, F. M.......New York, N. Y.
Farmer, J. T....Montreal, Que., Can.
Farnham, B. B........Buffalo, N. Y.
Farnham, D. T......Westport, Conn.
Farnham, D. W...............
Barranca-Bermeja, Colombia, S. A.
Farnham, G. W.......Scranton, Pa.
Farnham, W. E...Tufts College, Mass.
Farnsworth, A. J.Los Angeles, Calif.
Farny, G. W....Morris Plains, N. J.
Farquhar, F..............York, Pa.
Farquhar, L. C......E. St. Louis, Ill.
Farquhar, M. T.....Worcester, Mass.
Farr, D. E........E. Pittsburgh, Pa.
Farr, M. S.........Los Angeles, Calif.
Farr, W. G............S. Orange, N. J.
Farr, W. S.........Washington, D. C.
Farrand, E. G..........Chicago, Ill.
Farrell, E. F..........Detroit, Mich.
Farrell, F. L..........Boston, Mass.
Farrell, J. A., Jr....New York, N.Y.
Farrell, J. M.........Lebanon, Kan.
Farrell, J. V.......Thomaston, Conn.
Farris, M. E..Albuquerque, New Mex.
Fassbender, W. J...Philadelphia, Pa.
Fast, G..............Baltimore, Md.
Fathauer, C. E..........Chicago, Ill.
Faulkner, C. L.........Atlanta, Ga.
Faulkner, D. S......Torrance, Calif.
Fausel, C. A.......Glen Ridge, N. J.
Faust, H. M.........Columbus, Ohio
Faust, P. A............Miami, Ariz.
Favorite, R. J..........Boston, Mass.
Fawcett, H. N........Ossining, N. Y.
Faxon, F. E..Wappingers Falls, N. Y.
Faxon, H. C.Singapore, Malay Penin.
Fay, C. H............Newark, N. J.
Fayles, R. R...........Troy, N. Y.
Faymonvile, P. R.Moscow, U. S. S. R.
Fazioli, J. J.........Hartford, Conn.
Feagles, R. L...Oklahoma City, Okla.
Fear, S. L.......Toronto, Ont., Can.
Fechheimer, C. J....Milwaukee, Wis.
Fedde, A. M.........Brooklyn, N. Y.
Fee, H. R...........New York, N. Y.
Feeney, J. P..........Kearny, N. J.
Feher, L. L.......Mt. Vernon, N. Y.
Fehr, R. B..........Cleveland, Ohio
Feicht, E. R........Philadelphia, Pa.
Feige, W............Detroit, Mich.
Feiker, F. M......Washington, D. C.
Feiner, H...........Brooklyn, N. Y.
Fekete, L. A.........Brooklyn, N. Y.
Feldman, A. M......New York, N. Y.
Felgar, J. H.........Norman, Okla.
Felker, G. F........New York, N. Y.
Fell, H. P..........New York, N. Y.
Fellows, E. R.......Springfield, Vt.
Fellows, O. B.....Middletown, N. Y.
Felten, J. M..Sao Paulo, Brazil, S. A.
Feltham, D. L.........Toledo, Ohio
Felton, E. C.......Philadelphia, Pa.
Felton, G. W......Springville, N. Y.
Femal, E. J.........Appleton, Wis.
Fendrich, C. N..........Steelton, Pa.
Fenn, E. P..Washington Depot, Conn.
Fenton, T. A., Jr.....Norwich, Conn.
Fenwick, H. H.......Louisville, Ky.
Ferar, R.............Detroit, Mich.
Ferenzak, G. W......New York, N. Y.
Ferguson, A. R..........Joliet, Ill.
Ferguson, D.........Brooklyn, N. Y.
Ferguson, H. S.....New York, N. Y.
Ferguson, H. M.Salt Lake City, Utah
Ferguson, J. F.........Chicago, Ill.
Ferguson, J. W.......Paterson, N. J.
Ferguson, L. A., Jr.....Chicago, Ill.
Ferguson, R. B.....New York, N. Y.
Ferguson, W........Hartford, Conn.
Fergusson, D.........Rochester, N. Y.
Fernald, E. M...........Easton, Pa.
Fernald, H. B., Jr...........
Upper Montclair, N. J.
Fernald, R. H......Philadelphia, Pa.
Fernow, B. E..Clemson College, S. C.
Fernstrom, F. S.....Philadelphia, Pa.
Ferrero, H..........New York, N. Y.
Ferretti, A. J..........Boston, Mass.
Ferrier, F. M....San Francisco, Calif.
Ferrini, H. P......Jersey City, N. J.
Ferris, C. E........Knoxville, Tenn.
Ferris, D. M..........Detroit, Mich.
Ferris, Edwin A.....New York, N. Y.
Ferris, Ervie A., Jr...Oakland, Calif.
Ferris, J. P.........Knoxville, Tenn.
Ferris, J. T.........E. Chicago, Ind.
Ferris, R....Bogota, Colombia, S. A.
Ferris, W...........Milwaukee, Wis.
Ferry, J. M., Jr.....New York, N. Y.
Ferry, R. M....New Kensington, Pa.
Fersing, L...........Springfield, Vt.
Fertig, E. J...........Monroe, Mich.
Fertig, J. L...Albuquerque, New Mex.
Fessenden, E. A...........Troy, N. Y.
Fetters, G. H.....Gloversville, N. Y.
Feuchter, R............Chicago, Ill.
Few, E. L......Niagara Falls, N. Y.
Fexas, M..............Brooklyn, N. Y.
Feyling, G. T....Huntington, W. Va.
Feyling, P. L. F....Cambridge, Mass.
Fezandié, E. H.........Hoboken, N. J.
Fiala, S. N...........Passaic, N. J.
Ficco, F., Jr.......New York, N. Y.
Ficnerski, P. P.......Milwaukee, Wis.
Fidelius, W. R......Brooklyn, N. Y.
Fidler, I............High Point, N. C.
Fiedler, A....Vitry-sur-Seine, France
Fiege, H. J........Waterbury, Conn.
Field, C.............Brooklyn, N. Y.
Field, D. A..........Stafford, England
Field, D. P......W. Somerville, Mass.
Field, E. G.............Atlanta, Ga.
Field, E. J........Minneapolis, Minn.
Field, F. C........Philadelphia, Pa.
Field, L. N.........E. Lansing, Mich.
Field, W. T.........Watertown, N. Y.
Fielman, W. E. M...Cincinnati, Ohio
Fiero, C. D...........Batavia, N. Y.
Fierro, S..............Mexico, Mex.
Figelman, B.................
Huntington Station, L. I., N. Y.
Fihe, J. L...............Akron, Ohio
Filer, J.........Port Reading, N. J.
Files, W. R........Providence, R. I.
Fimian, R............Peekskill, N. Y.
Finch, C. V.........Berkeley, Calif.
Finch, F. R........Ann Arbor, Mich.
Finch, S. B.........Brooklyn, N. Y.
Finch, V. C.Stanford University, Calif.
Fincke, D. M.........Brooklyn, N. Y.
Findlater, S.........Pittsburgh, Pa.
Fine, B. M.........Philadelphia, Pa.
Fine, L.............Bethlehem, Pa.
Fine, M. E.........New York, N. Y.
Finigan, R. J.......E. Orange, N. J.
Fink, E. C...Long Island City, N. Y.
Fink, F...............Newark, N. J.
Fink, G. E..........New York, N. Y.
Fink, H.................Moline, Ill.
Fink, M..............New York, N. Y.
Finke, F. W., Jr.....New York, N. Y.
Finkel, J. J.........Brooklyn, N. Y.
Finkelstein, P..........Rome, N. Y.
Finkle, F. C.........Burbank, Calif.
Finlay, W. S., Jr....New York, N. Y.
Finn, H. R.........Springfield, Vt.
Finn, W. J...........Beacon, N. Y.
Finnegan, J. B.........Chicago, Ill.
Finneran, J. E., Jr..Columbus, Ohio
Finney, J. H. V....Washington, D. C.
Finney, W. R...........Tulsa, Okla.
Finster, G. C.........N. Bergen, N. J.
Firestone, S.........Rochester, N. Y.
Firing, W..............Oslo, Norway
Fisch, J..................York, Pa.
Fischer, A. K.......Philadelphia, Pa.
Fischer, E. G......E. Pittsburgh, Pa.
Fischer, H. L........St. Paul, Minn.
Fischer, H. O. A.........Chicago, Ill.
Fischer, J. C.......Wauwatosa, Wis.
Fischer, K. M.........Wyncote, Pa.
Fischman, S. O.........Chicago, Ill.
Fish, E. R..........Hartford, Conn.
Fish, J. A......Niagara Falls, N. Y.
Fisher, C. E., Jr....Peekskill, N. Y.
Fisher, D. A........New York, N. Y.
Fisher, D. F..........Trenton, N. J.
Fisher, D. G.........Walpole, Mass.
Fisher, E. C........Whippany, N. J.
Fisher, F..............Chicago, Ill.
Fisher, F. F............Chicago, Ill.
Fisher, F. P..........Detroit, Mich.
Fisher, G. H. B...Toronto, Ont., Can.
Fisher, G. K.......Philadelphia, Pa.
Fisher, H. C........Pawtucket, R. I.
Fisher, H. D......New Haven, Conn.
Fisher, I. M........New York, N. Y.
Fisher, J. F..........Albany, N. Y.
Fisher, R. T...........Boston, Mass.
Fisher, V. H.........Andover, N. H.
Fisher, W. J...............York, Pa.
Fisher, W. W..........Orange, N. J.
Fisk, G. L.........New York, N. Y.
Fiske, R. T.........Wilkinsburg, Pa.
Fitch, C. E...........Wilmette, Ill.
Fitch, H. W............Albany, N. Y.
Fitch, K. S.......Sacramento, Calif.
Fitch, W. K.........Pittsburgh, Pa.
Fitchett, F..............Rugby, Eng.
Fiterman, M. B.....New York, N. Y.
Fitton, W. H. B...New Haven, Conn.
Fitts, J. L......Merchantville, N. J.
Fitz, A. E.............Bristol, Conn.
Fitz, E. M........Worthington, Ohio
Fitze, M. E.........Milwaukee, Wis.
Fitzgerald, C.........Ft. Worth, Tex.
Fitz-Gerald, G.......Metuchen, N. J.
Fitzgerald, J. F.......Detroit, Mich.
Fitzgerald, J. M....Philadelphia, Pa.
FitzGerald, J. W.....Berlin, Germany
FitzGerald, T. F..........Troy, N. Y.
FitzGerald, W. E.....Shreveport, La.
Fitzhugh, R. R........Freeport, Tex.
Fitzmaurice, G. W.............
San Francisco, Calif.
Fitzpatrick, F. R...New York, N. Y.
Fitzsimmons, A. M. R.........
New York, N. Y.
Fitzsimmons, J. H...Brooklyn, N. Y.
Fitzsimmons, S. D..Providence, R. I.
FitzSimons, W. H., Jr........
Greenville, S. C.
Fixman, C. M.........St. Louis, Mo.
Flack, A...........New York, N. Y.
Flad, E................St. Louis, Mo.
Flagg, C. N., Jr......Meriden, Conn.
Flanagan, W. N......Pittsburgh, Pa.
Flanders, R. E......Springfield, Vt.
Flanders, W. B.....Philadelphia, Pa.
Flanigan, G. P..........Akron, Ohio
Flateboe, E. I.........Everett, Wash.
Flater, H.........Norrkoping, Sweden
Flather, F. A...........Lowell, Mass.
Flavin, E. J........New York, N. Y.

Fleet, S............New York, N. Y.
Fleischmann, W. L..Bloomfield, N. J.
Fleisher, H.........Brooklyn, N. Y.
Fleisher, W. L......New York, N. Y.
Fleming, A. P. M...Manchester, Eng.
Fleming, B. G.........Newark, Ohio
Fleming, H. S......New York, N. Y.
Fleming, J. C......Port Arthur, Tex.
Fleming, J. T.....Glasgow, Scotland
Fleming, L. T......Santa Cruz, Calif.
Fleming, T., Jr......Pasadena, Calif.
Fleming, T. F..........Chicago, Ill.
Fleming, W. M......Arlington, N. J.
Flentie, J. L.........Springfield, Ill.
Flesher, M. G...........Chicago, Ill.
Fletcher, A. R..........Canton, Mass.
Fletcher, F. R.........Boston, Mass.
Fletcher, H. O......Brooklyn, N. Y.
Fletcher, H. W........Houston, Tex.
Fletcher, J..........Barberton, Ohio
Fletcher, J. L....Schenectady, N. Y.
Fletcher, N. R......Philadelphia, Pa.
Fletcher, R. L......Providence, R. I.
Fliflet, T...........New York, N. Y.
Flink, A. A.........Pittsburg, Calif.
Flink, A. E.........Alameda, Calif.
Flinn, M. S............Chicago, Ill.
Flinner, A. O..........Boston, Mass.
Flint, B. P.........Montclair, N. J.
Flint, C. K........Rochester, N. Y.
Flint, T...........Cambridge, Mass.
Flint, W. E.........Harrison, N. J.
Flockhart, J........New York, N. Y.
Flood, H..........New York, N. Y.
Floodeen, E..........Seattle, Wash.
Floras, C. L.........Athens, Greece
Florcyk, E. M.......Rockaway, N. J.
Floro, M..............Manila, P. I.
Flory, A. C.........Milwaukee, Wis.
Flower, A. D.........Upper Darby, Pa.
Flower, H. R.................
Frontino, Colombia, S. A.
Flower, T. R.......New Orleans, La.
Flowers, A. E....Poughkeepsie, N. Y.
Fluri, C. B........New York, N. Y.
Flynn, C. A.........New York, N. Y.
Flynn, J. H.....New Rochelle, N. Y.
Flynn, M. H.........Hartford, Conn.
Flynn, W. H.........New York, N. Y.
Flynn, W. S............Troy, N. Y.
Fodor, N..........Wauwatosa, Wis.
Fogarty, M. J.......Brooklyn, N. Y.
Fogarty, W. B......Cincinnati, Ohio
Fogelson, E........New York, N. Y.
Fogg, E. S........Providence, R. I.
Fogg, O. H.........New York, N. Y.
Fogg, W. R.......Philadelphia, Pa.
Fogle, P. A.........Columbus, Ohio
Fogler, B. B.......Cambridge, Mass.
Foley, G. B.................
Smooth Rock Falls, Ont., Can.
Foley, J. A........Jersey City, N. J.
Foley, W. J.........Honolulu, T. H.
Follari, S...........Brooklyn, N. Y.
Folse, J. A............Chicago, Ill.
Folsom, R. G.........Berkeley, Calif.
Foltan, L...........New York, N. Y.
Foltz, R. D........New York, N. Y.
Fontenay, L. L.....Address Unknown
Foord, J. L..........Auburn, N. Y.
Foote, L........Pedro Miguel, C. Z.
Forbes, J. B........New York, N. Y.
Forbes, R. T..........Boston, Mass.
Forbes, W. G.........Albany, N. Y.
Ford, A. R.......Minneapolis, Minn.
Ford, A. S...........Lithgow, Aust.
Ford, F. H...........Anaheim, Calif.
Ford, Henry..........Detroit, Mich.
Ford, Howard......New York, N. Y.
Ford, H. P...........Seattle, Wash.
Ford, H. S............Detroit, Mich.
Ford, L. R.........New York, N. Y.
Ford, R. E.......Minneapolis, Minn.
Fordham, N. E........Denver, Colo.
Fordyce, J. R......Little Rock, Ark.
Foresman, R. A....Philadelphia, Pa.
Forfar, D. M......Minneapolis, Minn.
Forman, A. H........Baltimore, Md.
Forman, W. W.....Waterbury, Conn.
Forney, J. R......Washington, D. C
Forrest, G. M......New York, N. Y.
Forrest, J..........Barberton, Ohio
Forschner, A. J.....Philadelphia, Pa.
Forsman, E. J.......New York, N. Y.
Forssell, A. G....Baldwinsville, N. Y.
Forstall, A. E.......Montclair, N. J.
Forster, C. P.........Aruba, D. W. I.
Forster, J. A............Troy, N. Y.
Forsythe, C. E..........Detroit, Mich.
Forsythe, C. F..Townley-Union, N. J.
Fortmann, E. H........Oil City Pa.
Fortney, C. P....Charleston, W. Va.
Fortune, W. B..........Easton, Pa.
Fosdick, W. P......Cincinnati, Ohio
Foss, F. F........Wheeling, W. Va.
Foster, A. C........New York, N. Y.
Foster, C............Duluth, Minn.
Foster, C. A. B......Richmond, Va.
Foster, C. C.......Maplewood, N. J.
Foster, C. H............Troy, N. Y.
Foster, E. H..........Florence, Italy
Foster, E...........New York, N. Y.
Foster, F. G..........Andalusia, Pa.
Foster, G. T....New Rochelle, N. Y.
Foster, J. S.........Elizabeth, N. J.
Foster, N. S..........Kearny, N. J
Foster, R. E., Jr....New York, N. Y.
Foster, S. L., Jr....Lawrence ,Mass.
Foster, Walter H......Lewistown, Pa.
Foster, Willard H......Boston, Mass.
Foster, W. I........Allentown, Pa.
Foster, W. N............Peoria, Ill.
Fotter, M. J..........Chicago, Ill.
Foulds, C. V.................
Barranquilla, Colombia, S. A.
Foulds, J. C......Hutchinson, Kan.
Fournier, T. F....Los Angeles, Calif.
Foust, S. A..........Whiting, Ind.
Fowden, W........Rapid City, S. D.
Fowler, E. L.................
Jackson Heights, L. I., N. Y.
Fowler, F. R.....Schenectady, N. Y.
Fowler, H. C., Jr.....Louisville, Ky.
Fowler, H. E.........Rochester, N. Y.
Fowler, R. W..........Ogden, Utah
Fox, A. W........New York, N. Y.
Fox, B...............Quincy, Mass.
Fox, C. H...........Cincinnati, Ohio
Fox, F. H.............Reading, Pa.
Fox, F. W..........Elizabeth, N. J.
Fox, J. F........Washington, D. C.
Fox, J. H............Pittsburgh, Pa.
Fox, R. H............Denver, Colo.
Fox, Ralph W..Montour Falls, N. Y.
Fox, Raymond W..Charleston, W. Va.
Fox, W................Orlando, Fla.
Fox, W. B........Philadelphia, Pa.
Frack, M. W...........Tulsa, Okla.
Fradenburgh, J....Amsterdam, N. Y.
Fraint, S..........New York, N. Y.
Fralich, J. S. Y.......Chicago, Ill.
Frame, C. C..........Wabash, Ind.
Frame, W. M.........Ambridge, Pa.
France, E. G..........S. Bend, Ind.
France, W. H...........Slough, Eng.
Francis, T. M.......Birmingham, Ala.
Francisco, F. L. R..New York, N. Y.
Frank, A. C......Yates Center, Kan.
Frank, A. S.........Philadelphia, Pa.
Frank, C. F. W.....Cincinnati, Ohio
Frank, E...........Milwaukee, Wis.
Frank, G. M............Lima, Ohio
Frank, M..........New York, N. Y.
Frank, O. E........New York, N. Y.
Frank, P. E........New York, N. Y.
Frank, R. A.........Brooklyn, N. Y.
Frank, R. M........New York, N. Y.
Frankena, A.........Baltimore, Md.
Frankenberg, T. T....Power, W. Va.
Frankenfield, C. W....Bayonne, N. J.
Frankenhoff, C. A...New York, N. Y.
Frankenhoff, E. T......Chicago, Ill.
Franklin, B. A.....Springfield, Mass.
Franklin, E. J...Salt Lake City, Utah
Franklin, P. A.................
Port Washington, L. I., N. Y.
Franks, F. B..........Brodhead, Pa.
Frankum, J. B........Denver, Colo.
Frankum, J. L..........Alcoa, Tenn.
Frankum, R. O......Memphis, Tenn.
Fransioli, V. G......Memphis, Tenn.
Fransioli, W. J., Jr...Memphis, Tenn.
Franz, E. E..........Kearny, N. J.
Franz, F..........New Haven, Conn.
Frarey, E. F..........S. Bend, Ind.
Fraser, N. D...........Chicago, Ill.
Fraser, O. B. J.....New York, N. Y.
Fraser, P. V.........Cleveland, Ohio
Fraser, T. T...........Danvers, Mass.
Frasier, J. L........Hoopeston, Ill.
Frauenthal, H. L.Mineola, L. I., N. Y.
Frautschi, C...........Toledo, Ohio
Frawley, P. J..........St. Paul, Minn.
Frear, H. P........New York, N. Y.
Freas, R. B............Chicago, Ill.
Frede, C. F.......Granite City, Ill.
Frederick, E. A......Detroit, Mich.
Free, A. V..........Yonkers, N. Y.
Free, L. W......Los Angeles, Calif.
Free, W. M......Elizabethton, Tenn.
Freed, L...............Toledo, Ohio
Freed, L. J.........New York, N. Y.
Frederick, R. H...High Bridge, N. J.
Freedley, P.........Philadelphia, Pa.
Freeland, E. C......New York, N. Y.
Freeland, W. W.................
Brownsburg, Que., Can.
Freeman, A. B....Los Angeles, Calif.
Freeman, B.........Cleveland, Ohio
Freeman, B. W......Cincinnati, Ohio
Freeman, C........Providence, R. I.
Freeman, C. L........Baltimore, Md.
Freeman, E. W......Providence, R. I.
Freeman, F. C......Providence, R. I.
Freeman, F. S.........Boston, Mass.
Freeman, H. L.....Birmingham, Ala.
Freeman, H. S......Rochester, N. Y.
Freeman, H. T......Providence, R. I.
Freeman, L. D....Washington, D. .C
Freeman, M. F........Boston, Mass.
Freeman, P. J......Knoxville, Tenn.
Freeman, R. B......Torrance, Calif.
Freer, H. L........Springfield, Mass.
Freer, W. G......Schenectady ,N. Y.
Freese, C. E........Cleveland, Ohio
Freiday, J. A.......E. Orange, N. J.
Freiman, E. P..........Chicago, Ill.
Freitag, H. W......Brooklyn, N. Y.
Fremon, E. B........St. Louis, Mo.
Fremont, E. G....Birmingham, Mich.
Fremont, W. O....Ann Arbor, Mich.
French, D. K..........Chicago, Ill.
French, E. V.........Boston, Mass.
French, F. W......Waterbury, Conn.
French, K. A..........Exeter, N. H.
French, T. E........Columbus, Ohio
Freshwater, E. S....Cincinnati, Ohio
Fretter, N. F........Cleveland, Ohio
Freund, C. J.........Detroit, Mich.
Freund, H. R.......New York, N. Y.
Freund, K..............Akron, Ohio
Frewin, L......Salt Lake City, Utah
Frey, A. C............Camden, N. J.
Frey, A. T..............Flint, Mich.
Frey, G. J.........Cincinnati, Ohio
Frey, R. E...........Lancaster, Pa.
Freyermuth, G. H..New York, N. Y.
Freyn, H. J............Chicago, Ill.
Freyschmidt, C.....New York, N. Y.
Frick, C. H.........Allentown, Pa.
Fricker, J. E........Stamford, Conn.
Fried, J. A...........Ithaca, N. Y.
Friedeberg, S. E....New York, N. Y.
Friedlander, E. A.....Brooklyn, N. Y.
Friedline, J. M...Cedar Rapids, Iowa
Friedman, F. J..Montreal, Que., Can.
Friedman, G..Long Island City, N. Y.
Friedman, J. H...........Tiffin, Ohio
Friedman, M.......New York, N. Y.
Friend, J. H...........Mobile, Ala.
Friend, W. F.......New York, N. Y.
Fries, G. S............Reading, Pa.
Frigiola, N. F....W. New York, N. J.
Frisch, M..........New York, N. Y.
Fritsche, C. B.........Detroit, Mich.
Fritts, S. S.......Phillipsburg, N. J.
Fritz, C. G.............Fords, N. J.
Fritzsch, T. N........Johnstown, Pa.
Froberg, H. G.........Chicago, Ill.
Froehlich, F. H.........Toledo, Ohio
Froelich, F. C.................
Charlottenburg, Germany.
Frohlin, J............Bayonne, N. J.
Frohmuth, R. L..Newport News, Va.
Frohrieb, L. C.......Pittsburgh, Pa.
Frolander, F. C......Brooklyn, N. Y.
Fromm, C..........Harrison, N. J.
Fromm, H. H......New York, N. Y.
Frost, E. J..........Jackson, Mich.
Frost, F. G.........New Orleans, La.
Frost, V. M..........Newark, N. J.
Fry, A. H..............Chicago, Ill.
Fry, C. V..........Cambridge, Mass.
Fry, H. P..........Philadelphia, Pa.
Fry, H. S............Rochester, Pa.
Fry, L. H...........Pittsburgh, Pa.
Fryer, R. L., Jr....Cleveland, Ohio
Fuchs, C. A.....Freeport, L. I., N. Y.
Fuente, B............Sylvania, Ohio
Fuerchtgott, M. J....Brooklyn, N. Y.
Fuhrmann, F. A.................
Patchogue, L. I., N. Y.
Fuhrmann, O. W....New York, N. Y.
Fuller, C. E.......Cambridge, Mass.
Fuller, E. H..........Detroit, Mich.
Fuller, E. W............Dallas, Tex.
Fuller, F. M.........Allentown, Pa.
Fuller, G. B........Inglewood, Calif.
Fuller, G. F........Worcester, Mass.
Fuller, J. H.......Wilmington, Del.
Fuller, R. B........Biltmore, N. C.
Fuller, V. E.........Charlotte, N. C.
Fuller, W. D.......Philadelphia, Pa.
Fullerton, H. P....Philadelphia, Pa.
Fullman, C. A.................
Huntington Park, Calif.
Fullmer, I. H.....Washington, D. C.
Fulton, G. R..........Beaumont, Tex.
Fulton, W. B..Hermosa Beach, Calif.
Fulweiler, J. E....Philadelphia, Pa.
Fulweiler, W. H....Wallingford, Pa.
Funch, E. E........New York, N. Y.
Funk, N. E........Philadelphia, Pa.
Funk, W. F..........LaCrosse, Wis.
Furchgott, A. C., Jr.New Orleans, La.
Furman, F. DeR.......Hoboken, N. J.
Furman, J........Philadelphia, Pa.
Furman, L. J.......Worcester, Mass.
Furnas, V. E., Jr....Louisville, Ky.
Furrer, R..........Milwaukee, Wis.
Fykse, M. L......S. Milwaukee, Wis.
Fynboe, C........Binghamton, N. Y.

G

Gabla, P. F..........Lahore, India
Gabor, H. W.......New York, N. Y.
Gabriel, E. Z........Montclair, N. J.
Gabriel, W. A.............Elgin, Ill.
Gaddis, H. L............Dallas, Tex.
Gaehr, D............Cleveland, Ohio
Gaffert, G. A..........Chicago, Ill.
Gaffney, J. B........Catasauqua, Pa.
Gage, V. R............Ithaca, N. Y.
Gagg, R. F..........Paterson, N. J.
Gahnkin, V. G......Brooklyn, N. Y.
Gail, G. W..........Baltimore, Md.
Gaillard, D. St. P..Washington, D. C.
Gaillard, J.........New York, N. Y.
Gaines, E. C...........Chicago, Ill.
Gaither, R. H..........Ridgway, Pa.
Galaher, F. B......Watertown, Mass.
Galata, R..........Brooklyn, N. Y.
Galbreath, P. J......Pittsburgh, Pa.
Gale, H. B............Natick, Mass.
Gale, P. B..........Hartford, Conn.
Gale, P. C......Michigan City, Ind.
Gale, W. D............Mexico, Mex.
Gall, W. R........Rogersville, Tenn.
Gallagher, E. E.....St. James, Mich.
Gallagher, E. G..Toronto, Ont., Can.
Gallagher, H. J......Brooklyn, N. Y.
Gallagher, J. J....New York, N. Y.
Gallagher, J. S....Los Angeles, Calif.
Gallagher, L. H......Stratford, Conn.
Gallagher, T. G., Jr.........
Sault Ste. Marie, Ont., Can.
Gallaher, A. H......Plainfield, N. J.
Gallaher, E. B.......Norwalk, Conn.
Gallalee, J. M......University, Ala.
Gallaway, H. M..........Reno, Nev.
Gallenkamp, E. W., Jr..Chicago, Ill.
Gallese, J. J......Lima, Peru, S. A.
Gallik, J. J.........Pittsburgh, Pa.
Gallo, A. E.........Brooklyn, N. Y.
Galloway, C. D....Philadelphia, Pa.
Galloway, F. M...............
Buenos Aires, Argentina, S. A.
Galloway, J. W..Hamilton, Ont., Can.
Galloway, L........New York, N. Y.
Galloway, R. R....Washington, D. C.
Galloway, W. C....E. Orange, N. J.
Galloway, Walter S...Baltimore, Md.
Galloway, Wm. S..Birmingham, Ala.
Gallup, R. L...........Chicago, Ill.
Galson, H. L.......Philadelphia, Pa.
Galusha, A. L........Caldwell, N. J.
Galvin, J. E............Lima, Ohio
Gambert, G. W.......Buffalo, N. Y.
Gamble, W. W......Elizabeth, N. J.
Gamewell, J. McD..Lexington, N. C.
Gammeter, H. C....Cleveland, Ohio
Gammon, R. C.......Detroit, Mich.
Gang, O. F.........Scarsdale, N. Y.
Gangewere, E. P........Reading, Pa.
Gannon, J........Los Angeles, Calif.
Gannon, T. J.......New York, N. Y.
Gano, H. M...........Dayton, Ohio
Garbe, H. W...........Chicago, Ill.
Garbett, B. C.....Minneapolis, Minn.
Garcia, P..............Manila, P. I.
Garden, N. B.......New York, N. Y.
Gardiner, C. M....Schenectady, N. Y.
Gardner, D. A....Wilmington, N. C.
Gardner, L. D......New York, N. Y.
Gardner, L. R......New York, N. Y.
Gardner, M. E.........Dayton, Ohio
Gardner, R.......Los Angeles, Calif.
Gardner, S. F....Washington, D. C.
Gardner, W. W........Lancaster, Pa.
Garey, G. W..Tocopilla, Chile, S. A.
Garey, L. L..........Newark, N. J.
Garfield, A. S..........Paris, France
Garger, J. H., Jr....New York, N. Y.
Garges, J. P. D.................
Farmingdale, L. I., N. Y.
Garland, C. M..........Chicago, Ill.
Garland, J.......Montreal, Que., Can.
Garneau, L. A........Newport, R. I.
Garner, E. F..........Ithaca, N. Y.
Garnier, A.....................
Villefranche-sur-Mer, France
Garnsey, H., Jr..Seneca Falls, N. Y.
Garratt, E. A..........London, Eng.
Garretson, F. M....New York, N. Y.
Garretson, H. C., Jr..Springfield, Mass.
Garrett, E. E., Jr.............
Long Island City, N. Y.
Garrett, E. H.......Lebanon, N. H.
Garrett, J. A.....S. Pasadena, Calif.
Garrett, R. E......Philadelphia, Pa.
Garrett, R. M.......Sheboygan, Wis.
Garrett, S. S..........Ithaca, N. Y.
Garrett, W. S..........Roanoke, Va.
Garrison, R. M........Houston, Tex.

Garrison, W. L.....New York, N. Y.
Garsed, E. T........Charlotte, N. C.
Garski, A..........Wakefield, Mich.
Garson, H. N..Kristiansand, Norway
Garson, T. N.......New York, N. Y.
Gartmann, H.........Trenton, N. J.
Gartz, W. J............Chicago, Ill.
Gary, F. P...........St. Louis, Mo.
Gaskin, G. H.......New York, N. Y.
Gassett, P. L..........Tulsa, Okla.
Gassmann, J. A....Valley City, N. D.
Gast, G. F..........Bayonne, N. J.
Gaston, A. D........Baytown, Tex.
Gaston, W. I..........Newark, N. J.
Gate, P. A..........Pasadena, Calif.
Gately, W. A.......New York, N. Y.
Gates, C. S.........Hartford, Conn.
Gates, E. L.........Milwaukee, Wis.
Gates, H. G........New Castle, Pa.
Gates, L. G........Bakersfield, Calif.
Gates, R. M.......New York, N. Y.
Gates, S. J..........Milwaukee, Wis.
Gatje, F. C........New York, N. Y.
Gaum, A. F........Winchester, Mass.
Gaum, C. G....New Brunswick, N. J.
Gausmann, R. W...............
Pernambuco, Brazil, S. A.
Gauss, H. F..........Moscow, Idaho
Gavett, J. W........Rochester, N. Y.
Gavit, W. P.........New York, N. Y.
Gawronski, H. S.....Milwaukee, Wis.
Gay, F. R..........Compton, Calif.
Gay, F. W..........Newark, N. J.
Gay, J. A..........Richmond, Calif.
Gayer, G. F..........Norwood, Pa.
Gaylord, L. T.......New York, N. Y.
Gaylord, W. W....New Haven, Conn.
Gayman, B. A...San Francisco, Calif.
Gayton, L. D..........Chicago, Ill.
Gazzam, J. P.........St. Louis, Mo.
Gearing, C. M........Bristol, Conn.
Gearon, G.............Chicago, Ill.
Gebhard, L. N........Taunton, Mass.
Gebhardt, G. F.........Miami, Fla.
Gebhardt, W. A......Cleveland, Ohio
Gebhart, H............Dayton, Ohio
Geck, D. P..........Cleveland, Ohio
Geddes, L. H.........Rockford, Ill.
Geddes, T. G........Torrance, Calif.
Gee, W. H........New York, N. Y.
Geenens, L..........New York, N. Y.
Geer, H. E............London, Eng.
Geerlings, H. J......Milwaukee, Wis.
Geers, J. F........Cincinnati, Ohio
Gefvert, C. J.......New York, N. Y.
Geier, F. V.........Cincinnati, Ohio
Geiger, J. W......W. Lafayette, Ind.
Geiger, W. C..........Sunbury, Pa.
Geisinger, J. M......Middletown, Pa.
Geissbuhler, J. O....Cleveland, Ohio
Geitmann, R. J........Oak Park, Ill.
Gellert, T..........Brooklyn, N. Y.
Gelter, S. V....San Francisco, Calif.
Gelzer, E..............Chicago, Ill.
Gendall, G. H., Jr...........
Rockville Center, L. I., N. Y.
Genereaux, R. P....Wilmington, Del.
Genest, H. A.........Danbury, Conn.
Gentzel, P. H.......Philadelphia, Pa.
Geoghegan, W. H. B...........
Charleston, W. Va.
George, F. X., Jr....Piedmont, Calif.
George, J. R.....Youngstown, Ohio
George, L. B.......New York, N. Y.
George, V. C......Los Angeles, Calif.
Gerber, S. R.........Brooklyn, N. Y.
Gerhard, H. W......New York, N. Y.
Gerken, H. A....Staten Island, N. Y.
Gerling, A.........Richmond, Calif.
German, A. J.......Waterbury, Conn.
German, W. W.........Butte, Mont.
Gerrish, L. M......La Romana, D. R.
Gersbach, H. A..Flushing L. I., N. Y.
Gershberg, J........New York, N. Y.
Gersoni, L. J.........Brooklyn, N. Y.
Gesell, W. H......Bloomfield, N. J.
Gess, L............Philadelphia, Pa.
Getchell, E. L........Durham, N. H.
Getsug, B...........St. Paul, Minn.
Getzen, J. E.......Birmingham, Ala.
Getzman, E. M......Pasadena, Calif.
Getzoff, E. M.......Bloomfield, N. J.
Geyer, H. E.........San Diego, Calif.
Gfrorer, A. H.......Morristown, N. J.
Gianelloni, V. J....San German, Cuba
Giardi, L. A........Hartford, Conn.
Gianque, R. E.......New York, N. Y.
Gibb, J. F.......Niagara Falls, N. Y.
Gibbas, L. J..........Cincinnati, Ohio
Gibbons, J. O. G....Bloomfield, N. J.
Gibbons, J. W.......Brooklyn, N. Y.
Gibbons, M. J., Jr......Dayton, Ohio
Gibbons, P. L........Brooklyn, N. Y.
Gibbs, C. J...........Berkeley, Calif.
Gibbs, C. R.......Kalamazoo, Mich.
Gibbs, F. O.......Kernersville, N. C.
Gibbs, G...........New York, N. Y.
Gibbs, R. E.......Minneapolis, Minn.
Gibby, W. F..........Buffalo, N. Y.
Gibling, H. F......Pawtucket, R. I.
Gibson, A. E.........Cleveland, Ohio
Gibson, F. M........Brooklyn, N. Y.
Gibson, G..........New York, N. Y.
Gibson, G. H.......New York, N. Y.
Gibson, H. D................
W. New Brighton, S. I., N. Y.
Gibson, H. L..........Detroit, Mich.
Gibson, J. E.......Charleston, S. C.
Gibson, N. R.........Buffalo, N. Y.
Gibson, R. F........New York, N. Y.
Gibson, R. M......Short Hills, N. J.
Gibson, W. R.........Seattle, Wash.
Giebner, J. H.......Washington, D. C.
Giddins, S. G........Brooklyn, N. Y.
Giegengack, A. E..Washington, D. C.
Giesecke, F. E....College Station, Tex.
Giesler, J. V........Knoxville, Tenn.
Giesl-Gieslingen, A...Brooklyn, N. Y.
Giffels, J. E..........Tenafly, N. J.
Gifford, A. J.........Worcester, Mass.
Gifford, C. R..........Detroit, Mich.
Gifford, J. F.....Windsor, Ont., Can.
Gifford, R. L..........Chicago, Ill.
Gil, R. I............Mayaguez, P. R.
Gilbert, C. F........Wadsworth, Ohio
Gilbert, C. L........Hartford, Conn.
Gilbert, E. C..........Boston, Mass.
Gilbert, E. M..........Reading, Pa.
Gilbert, K............Yonkers, N. Y.
Gilbert, K. C........New York, N. Y.
Gilbert, L. B........Wesleyville, Pa.
Gilbert, R. L.....London, Ont., Can.
Gilbert, W. W......Ann Arbor, Mich.
Gilbreth, L. M......Montclair, N. J.
Gilbreth, W. M.........Detroit, Mich.
Gilfillan, J. M.....Birmingham, Ala.
Gill, C. A............Reading, Pa.
Gill, J. R..............Enka, N. C.
Gill, N. F...........Cleveland, Ohio
Gillen, G. M.........Paterson, N. J.
Gilleo, W. F.......Bridgeport, Conn.
Giller, F. S.........Hextable, Eng.
Gillespie, F. M.......Galveston, Tex.
Gillespie, R. G...Toronto, Ont., Can.
Gillett, C. E........Worcester, Mass.
Gillett, J..............Toledo, Ohio
Gillette, E. S....Santa Monica, Calif.
Gillham, W. C.......Knoxville, Tenn.
Gilliam, C. C.......Ackerman, Miss.
Gilliam, H. H.........Paterson, N. J.
Gillie, D. R.........Brooklyn, N. Y.
Gillies, J. H..........Chester, Pa.
Gillig, G. J...........Buffalo, N. Y.
Gilligan, F. B...W. Carrollton, Ohio
Gilliland, L. R......Hoboken, N. J.
Gilling, E. N........Pittsburgh, Pa.
Gillis, H. A......Washington, D. C.
Gillis, I. V.......Washington, D. C.
Gillivan, C. Z........Columbus, Ohio
Gillroy, B. J........New York, N. Y.
Gilman, F. C.......Wuchang, China
Gilman, F. W.......Philadelphia, Pa.
Gilmore, A. M....Los Angeles, Calif.
Gilmore, G. M....Los Angeles, Calif.
Gilmore, J. W......New York, N. Y.
Gilroy, J. A...........Chicago, Ill.
Ginochio, C. E....Sacramento, Calif.
Ginsburg, J.........Worcester, Mass.
Girvin, C. J........Wilmington, Del.
Girvin, H. F.......W. Lafayette, Ind.
Gish, J. A., Jr.......Allentown, Pa.
Gisler, M..............Bradford, Pa.
Githens, T. F........Cleveland, Ohio
Gittelman, A. B....Philadelphia, Pa.
Gittens, E. D..........Roselle, N. J.
Gitzendanner, F. A., Jr.........
New York, N. Y.
Givan, A..........Sacramento, Calif.
Givens, G. C.........Brooklyn, N. Y.
Givens, H. C..........Avant, Okla.
Gladden, C. S..........Chicago, Ill.
Gladding, J. N., Jr..Charlotte, N. C.
Gladding, R. D.....High Point, N. C.
Gladeck, F. C.......Brooklyn, N. Y.
Glanville, R. H........Auburn, N. Y.
Glas, E. F...........New York, N. Y.
Glasby, J. B......Philadelphia, Pa.
Glaser, C. E.........Hamilton, Ohio
Glasgow, A. G........London, Eng.
Glasgow, C. L........Elizabeth, La.
Glasgow, C. O...........Tulsa, Okla.
Glasgow, J. G.......Pittsburgh, Pa.
Glasius, E............Detroit, Mich.
Glass, W. C..........New York, N. Y.
Glasser, H. C........Rochester, N. Y.
Glassey, P. P..........Albany, N. Y.
Glauch, E. S.......Jersey City, N. J.
Glazebrook, R. C........Beloit, Wis.
Gleason, G. H.........Boston, Mass.
Gleason, J. E........Rochester, N. Y.
Gleeson, F. T.........Cleveland, Ohio
Gleeson, J. M..................
Long Island City, N. Y.
Gleeson, W. S.... Brooklyn, N. Y.
Gleim, G. W.........Fishkill, N. Y.
Glenn, E. R........Philadelphia, Pa.
Glenn, G. W.......Philadelphia, Pa.
Glenn, J. R..........Pittsburgh, Pa.
Glennie, G. W.........Boston, Mass.
Glick, A. E...........St. Louis, Mo.
Glimm, W. F., Jr........Peoria, Ill.
Glinz, F.............Trenton, N. J.
Gloss, E. A........New York, N. Y.
Glossa, A. J...........Boston, Mass.
Glover, J. B...........Marietta, Ga.
Gloyer, W..........New York, N. Y.
Glueck, F. J.......Philadelphia, Pa.
Glynn, J. F., Jr.......Boston, Mass.
Gnade, E. R............Oil City, Pa.
Goard, L. L.........N. Canton, Ohio
Goddard, A. N........Detroit, Mich.
Godeke, H. F.........Lubbock, Tex.
Godfrey, R.........Philadelphia, Pa.
Godfrey, W. G........Buffalo, N. Y.
Godorov, S. J...........Reading, Pa.
Godschall, M. G......W. Lynn, Mass.
Godshall, W. H.......Lockport, N. Y.
Godsil, E. C....San Francisco, Calif.
Goebel, G. W.........La Jolla, Calif.
Goedecke, M..........Bristol, Conn.
Goegl, L. J.........E. Orange, N. J.
Goehring, W. W....Philadelphia, Pa.
Goeltz, P. H........Rochester, N. Y.
Goelz, A. H............Chicago, Ill.
Goentner, W. B.......Glenside, Pa.
Goerg, B............Yonkers, N. Y.
Goerg, E. F.......Jersey City, N. J.
Goetz, B. E............Chicago, Ill.
Goetz, H. E...............Erie, Pa.
Goetz, V. J........Philadelphia, Pa.
Goetze, F......New Brunswick, N. J.
Goetze, F. A........New York, N. Y.
Goetzenberger, R. L.Philadelphia, Pa.
Goff, J. A..............Urbana, Ill.
Goga, G. F.......Youngstown, Ohio
Golber, M. B...........Chicago, Ill.
Gold, D...........Indianapolis, Ind.
Gold, S. B.........Kansas City, Mo.
Goldberg, C. K..........Chicago, Ill.
Goldberg, H............Chicago, Ill.
Goldberg, M. M........Dayton, Ohio
Golden, R. F.........Newark, N. J.
Goldie, A. R.........Galt, Ont., Can.
Golding, H. B........Boston, Mass.
Goldman, F. D......New York, N. Y.
Goldman, O. G...San Francisco, Calif.
Goldrever, L. L..Jamaica, L. I., N. Y.
Goldsborough, W. E............
S. Norwalk, Conn.
Goldsbury, J.........W. Lynn, Mass.
Goldschmidt, O. E...New York, N. Y.
Goldsmith, C...........Chicago, Ill.
Goldsmith, L. M...Philadelphia, Pa.
Goldthwaite, H. W...Harrisburg, Pa.
Golladay, H. D.Wisconsin Rapids, Wis.
Gollin, C..............Chicago, Ill.
Gollmer, C. E........Hoopeston, Ill.
Golrick, M. A., Jr..............
Wappingers Falls, N. Y.
Gompertz, W.......Providence, R. I.
Gompf, A. M.........Baltimore, Md.
Gonter, R. J.........Baltimore, Md.
Gonzalez, E. D..........Banes, Cuba
Good, C. W........Ann Arbor, Mich.
Good, P. E...........Riverton, N. J.
Good, R. H.........Elizabeth, N. J.
Goodale, F..........Brooklyn, N. Y.
Goodall, R. G.........Burbank, Calif.
Goode, C. B..................
Turrialba, Costa Rica, C. A.
Goodnow, G. N...Birmingham, Mich.
Goodnow, J. M.........Boston, Mass.
Goodrich, C. W. McK...........
Niagara Falls, N. Y.
Goodrich, T. M........Albany, N. Y.
Goodwin, E. W....Washington, D. C.
Godwin, H., Jr.....Philadelphia, Pa.
Goodwin, J. L.......Hartford, Conn.
Goodwin, R. M....Philadelphia, Pa.
Goodwin, T. L., Jr...........
Flushing, L. I., N. Y.
Gopalakrishna, S....Bhadravati, India
Gorbutt, S. B.........Portland, Ore.
Gordon, B. B........Logansport, Ind.
Gordon, C. W..........Chicago, Ill.
Gordon, D.........Tarrytown, N. Y.
Gordon, E.........Williamsport, Md.
Gordon, E. M..........Chicago, Ill.
Gordon, G. L......Washington, D. C.
Gordon, G. W.......New York, N. Y.
Gordon, J. F.......Wilson Dam, Ala.
Gordon, M. B........Paterson, N. J.
Gordon, R. J........Dorchester, Mass.
Gordon, R. M........Syracuse, N. Y.
Gordon, R. T.......New York, N. Y.
Gordon, S..........New York, N. Y.
Gordon, W.........Brooklyn, N. Y.
Gordon, W. S., Jr...Philadelphia, Pa.
Gore, L. A.......Schenectady, N. Y.
Gorham, G. W., Jr............
Rocky Mount, N. C.
Gorham, W. R..........Tokyo, Japan
Gorman, W. R.........W. Allis, Wis.
Gormel, E. F.........Dansville, N. Y.
Gormel, E. M......Middleport, N. Y.
Gorney, H. S.......Wilmington, Del.
Gorrie, H. H..........Cleveland, Ohio
Gorrie, J. M.......Indianapolis, Ind
Gorton, C. E.........New York, N. Y.
Gorton, J. C.............Athol, Mass.
Goss, E. O.........Waterbury, Conn.
Goss, R. J.........New York, N. Y.
Goss, S. T.......New Britain, Conn.
Gosselin, E. N.............Joliet, Ill.
Gossman, A. L.....Los Angeles, Calif.
Gottlieb, E.........New York, N. Y.
Gottsch, D. C...Babylon, L. I., N. Y.
Gottsman, V..........Detroit, Mich.
Gotwals, C. S......Philadelphia, Pa.
Goudie, W. J......Glasgow, Scotland
Goudy, W., Jr..........Akron, Ohio
Gough, A. C........Pocatello, Idaho
Gough, J. B....Kenogami, Que., Can.
Gould, G. B........New York, N. Y.
Gould, J. U.........Brooklyn, N. Y.
Gould, L. J......Sparrows Point, Md.
Gould, N. J......Seneca Falls, N. Y.
Gould, T. L..........Berkeley, Calif.
Gounaris, B. V.....Watertown, Mass.
Gove, L. P............Boston, Mass.
Gow, R. F..........Worcester, Mass.
Gowen, J. R......Long Beach, Calif.
Gowling, L. R........Havana, Cuba
Grace, C. T.......New Haven, Conn.
Grace, J. F..........Harrison, N. J.
Grace, W. A...........Buffalo, N. Y.
Gracey, M., Jr.....Birmingham, Ala.
Grade, O. W.......Watertown, Mass.
Grady, C. B............Skytop, Pa.
Grady, J. J.........Paterson, N. J.
Graef, L. F............Hondo, Calif.
Graf, Albert J......New York, N. Y.
Graf, Andrew J......Cincinnati, Ohio
Graf, E. W..........Spokane, Wash.
Graf, J. C.........Philadelphia, Pa.
Graf, O. A...........Buffalo, N. Y.
Graf, S. H...........Corvallis, Ore.
Graf, W., Jr.........Harrison, N. J.
Graff, W. M........New York, N. Y.
Graffeo, J. A........Brooklyn, N. Y.
Graham, Clarence T............
Barrowsville, Mass.
Graham, Clifford T...Brooklyn, N. Y.
Graham, E. H..........Boston, Mass.
Graham, F. H........Pittsburgh, Pa.
Graham, J. M.......Cincinnati, Ohio
Graham, M., Jr.....New York, N. Y.
Graham, W. M.........Chicago, Ill.
Graham, W. W....Washington, D. C.
Graicunas, V. A....Kaunas, Lithuania
Gramp, A. N.....Moscow, U. S. S. R.
Granata, A. J........Brooklyn, N. Y.
Grand, S.............Detroit, Mich.
Grandinetti, J. R....Philadephia, Pa.
Grandle, P.......Long Beach, Calif.
Granfelt, E. H......Philadelphia, Pa.
Granger, A. D......New York, N. Y.
Granger, C. H.....Waterbury, Conn.
Granholm, J. A., Jr..New York, N. Y.
Grant, A. A........New Orleans, La.
Grant, H. C., Jr....New York, N. Y.
Grant, I. G.........St. Paul, Minn.
Grant, T. B........New York, N. Y.
Grant, U. J...........Rittman, Ohio
Grant, W. W...Old Greenwich, Conn.
Grantier, L. V........Detroit, Mich.
Grau, H. L.............Chicago, Ill.
Graves, B. P.......Providence, R. I.
Graves, C. R.........Brooklyn, N. Y.
Graves, G. R....Ft. Lauderdale, Fla.
Graves, W. J..........Detroit, Mich.
Gray, D. R..........Spokane, Wash.
Gray, F. R........New York, N. Y.
Gray, G. F..........Norwalk, Conn.
Gray, G. M..........Greenville, Pa.
Gray, H.............Galveston, Tex.
Gray, H. C.......Terre Haute, Ind.
Gray, H. L.........New York, N. Y.
Gray, J. E..........Galveston, Tex.
Gray, J. W..............Wayne, Pa.
Gray, N. A.........New York, N. Y.
Gray, P. S..........Honolulu, T. H.
Gray, W...........W. Lafayette, Ind.
Gray, W. A..........Richmond, Va.
Gray, W. K.....San Francisco, Calif.
Greagan, J. J......Birmingham, Ala.
Greaves, F. G.........Seattle, Wash.
Greaves, W. A...........Warren, Pa.
Grebe, J. J..........Midland, Mich.
Greeley, M. S............Bristol, Ill.
Green, A. B.........Needham, Mass.
Green, A. S.....San Francisco, Calif.
Green, B. H..........Syracuse, N. Y.
Green, B. M..................
Stanford University, Calif.
Green, F. W.........St. Louis, Mo.
Green, G. C.......New York, N. Y.
Green, H.............Detroit, Mich.

Green, J. O........Hattiesburg, Miss.
Green, J. S...........Buffalo, N. Y.
Green, L. A...........Madrid, Spain
Green, R. J..........Baltimore, Md.
Green, W...........Adelaide, Aust.
Green, W. H...........Chicago, Ill.
Green, W. L., Jr.....Brooklyn, N. Y.
Green, W. O............Chicago, Ill.
Green, W. P.......Washington, D. C.
Greenall, C. H......New York, N. Y.
Greenawalt, R. F.Phillipsburg, N. J.
Greenberg, B.........Newark, N. J.
Greenberg, M..........Chicago, Ill.
Greenberg, S.........New York, N. Y.
Greenblatt, L. W., Jr....Chicago, Ill.
Greene, A. M., Jr....Princeton, N. J.
Greene, C. E..........Boston, Mass.
Greene, E.............Boston, Mass.
Greene, E. W........Waipahu, T. H.
Greene, G. F........New York, N. Y.
Greene, I. C.......Address Unknown
Greene, L. S......New Canaan, Conn.
Greene, R. deC......New York, N. Y.
Greene, T. W......New York, N. Y.
Greenfield, B.........Linden, N. J.
Greenfield, B. S......New York, N. Y.
Greenhalgh, J....Framingham, Mass.
Greenhill, H...........Chicago, Ill.
Greenlaw, A. L........Rockland, Me.
Greenleaf, L. B..........Elkhart, Ind.
Greenman, H. M.........Chicago, Ill.
Greennan, E. G..........Chicago, Ill.
Greenwall, W. L....Milwaukee, Wis.
Greenwood, H.......New York, N. Y.
Greenwood, O. D...Los Angeles, Calif.
Greenwood, T. T.......Boston, Mass.
Greer, C. H..........Corning, N. Y.
Greer, E. S.........Zanesville, Ohio
Greger, A. F...........Harvey, Ill.
Greger, H...........Hamilton, Ohio
Gregersen, J.........Brooklyn, N. Y.
Gregg, F. D..........Maysville, Ky.
Gregory, D. J.........Allentown, Pa.
Gregory, J. N....Los Angeles, Calif.
Gregory, Wm. Benj..New Orleans, La.
Gregory, Wm. Bres......Dallas, Tex.
Greiner, C. J.........Menasha, Wis.
Greiner, F............Detroit, Mich.
Greist, A. O........New York, N. Y.
Gressly, O. E............Beaver, Pa.
Grether, E. C.......New York, N. Y.
Greul, W. H.......New York, N. Y.
Greve, E. E............Dallas, Tex.
Greyson, F. R.......Bonneville, Ore.
Gribbel, W. G.......Philadelphia, Pa.
Gridley, A. H.......New York, N. Y.
Griesenbeck, W...Schwelm, Germany
Grieshaber, E.......Milwaukee, Wis.
Griest, E. E.........Pittsburgh, Pa.
Grieve, A..........Lima, Peru, S. A.
Griffin, B.........Port Huron, Mich.
Griffin, C. L........San Diego, Calif.
Griffin, F. S............Akron, Ohio
Griffin, J. W.....Niagara Falls, N. Y.
Griffin, W. A.........Buffalo, N. Y.
Griffith, G. B.........Ft. Peck, Mont.
Griffith, L. M......Los Angeles, Calif.
Grigg, J. B.........Cleveland, Ohio
Griggs, R. A.......Jersey City, N. J.
Grimison, E. D......New York, N. Y.
Grimm, A.........Pearl River, N. Y.
Grimm, E. L.........St. Paul, Minn.
Grimmer, E. A.....Indianapolis, Ind.
Grimmett, E. J...Battle Creek, Mich.
Grimshaw, F. G........Altoona, Pa.
Grimshaw, W. F.......Denver, Colo.
Gring, W. D...........Newport, Pa.
Grisbaum, L. D....Indianapolis, Ind.
Griscom, E. W.....Marcus Hook, Pa.
Grise, R. A......New Britain, Conn.
Griswold, F., Jr....New York, N. Y.
Griswold, H. J...Montreal, Que., Can.
Griswold, H. L......Columbus, Ohio
Griswold, N. D.......Marquette, Mich.
Griswold, R. G......New York, N. Y.
Griswold, T., Jr......Midland, Mich.
Grob, J. J........New York, N. Y.
Grodner, A..........Pittsburgh, Pa.
Groene, W. F.......Cincinnati, Ohio
Groff, H. M...........Meadville, Pa.
Groff, J. C..........Bethlehem, Pa.
Groff, W. C............St. Louis, Mo.
Grohmann, C. L...W. Hartford, Conn.
Gronbach, J. H......Cleveland, Ohio
Gronemeyer, G. E....Cleveland, Ohio
Groom, J. H........Cincinnati, Ohio
Groome, W....Prince Bay, S. I., N. Y.
Groothuis, H.......Philadelphia, Pa.
Groschoff, E. H.Elmhurst, L. I., N. Y.
Groseclose, F. F...Chapel Hill, N. C.
Gross, C. M.........Anderson, Ind.
Gross, E. W........Fitchburg, Mass.
Gross, M. F..........Gramercy, La.
Gross, S...........Philadelphia, Pa.
Grossenbacher, E......Fajardo, P. R.
Grossheim, M. K....Glen Rock, N. J.
Grossman, L.......New York, N. Y.
Grossman, P. R......Cleveland, Ohio
Grossman, W.......Brooklyn, N. Y.
Groundwater, W. H.....Chicago, Ill.
Grove, W. G...........Mexico, Mex.
Grove, W. V...........Akron, Ohio
Grow, H. B..........Burbank, Calif.
Grow, J. A............Bradford, Pa.
Grow, O. W.......Philadelphia, Pa.
Growdon, J. P.......Pittsburgh, Pa.
Grubbs, L. W.........Louisville, Ky.
Grube, D. E..............Alton, Ill.
Gruber, C. W.......Cincinnati, Ohio
Gruber, G. J........Lawrence, Mass.
Grubman, M. T........Boston, Mass.
Gruenberg, O. C....New York, N. Y.
Gruendler, W. P.......St. Louis, Mo.
Grulick, F. K.......New York, N. Y.
Grunert, A. E..........Chicago, Ill.
Grunwald, L. J........S. Bend, Ind.
Grupe, W. F.........Garfield, N. J.
Grutle, R. O.....Twin Valley, Minn.
Grutzmacher, R. L............
San Francisco, Calif.
Grutzner, F. P..........Beloit, Wis.
Gubelman, F. J......Paterson, N. J.
Guden, J. C....Lynbrook, L. I., N. Y.
Gudmens, H. W.....Cincinnati, Ohio
Gudmundsen, A.....Milwaukee, Wis.
Guelbaum, D.......Address Unknown
Guerard, A. S., Jr...Coshocton, Ohio
Guerasimoff, C. N.......Harvey, Ill.
Guernsey, C. O.......Philadelphia, Pa.
Guest, A. R.........Brooklyn, N. Y.
Guest, J. R..........Buffalo, N. Y.
Guigou, M. A........New York, N. Y.
Guild, J.........Southbridge, Mass.
Guillet, G. L......State College, Pa.
Guillo, H. P.......New York, N. Y.
Guinan, J. F........Brooklyn, N. Y.
Guinnup, G. R..........Marion, Ind.
Guldberg, D. H.....Birmingham, Ala.
Gulick, H..........New York, N. Y.
Gulick, L. N.......Philadelphia, Pa.
Gulick, W. M.......New York, N. Y.
Gulliksen, J. W.....Edgewater, N. J.
Gullikson, A. C.Stanford Univ., Calif.
Gumaer, P. L.......New York, N. Y.
Gunagan, R. H......New York, N. Y.
Gunby, F. M..........Boston, Mass.
Gunderson, G. C..Perth Amboy, N. J.
Gunn, T. M........Woodbury, N. J.
Gunnell, B. C..........Spencer, N. C.
Gunning, W. A....Southbridge, Mass.
Gunther, C. O..........Nyack, N. Y.
Gunther, W..........Cleveland, Ohio
Gurin, H. M........New York, N. Y.
Gurney, D. A......Washington, D. C.
Gurney, W. B.....Baton Rouge, La.
Gurske, H. J.........Bristol, Conn.
Gus, C. E...........Brooklyn, N. Y.
Gustavsen, E.......New York, N. Y.
Gustavsen, J. A...New Britain, Conn.
Guther, G. W.......New York, N. Y.
Guthrie, A. N...........Ottawa, Ill.
Guthrie, D. F.........Maurer, N. J.
Guthrie, J. E...........Yancey, Ky.
Guthrie, J. F......Philadelphia, Pa.
Gutleben, D. C.San Francisco, Calif.
Guttmann, A. H.........Newark, N. J.
Guttormsen, P. A..E. Walpole, Mass.
Guy, H. L.........Manchester, Eng.
Guzzetti, A. J.Long Island City, N. Y.
Gwilliam, J..........Brooklyn, N. Y.
Gwynne, G. R..................
Chuquicamata, Chile, S. A.
Gysling, M. H...N. Tonawanda, N. Y.

H

Haag, J., Jr.........Brooklyn, N. Y.
Haag, P. H...São Paulo, Brazil, S. A.
Haager, P. L..........Canton, Ohio
Haar, S............New York, N. Y.
Haas, H. H.......Washington, D. C.
Habach, G. F........Harrison, N. J.
Habekotte, G. F....New York, N. Y.
Haber, H. E., Jr....New York, N. Y.
Habicht, E. R....Charlestown, W. Va.
Hacker, J. W...........Beaver, Pa.
Hackett, H. B......Philadelphia, Pa.
Hackett, R. S......Wilmington, Del.
Hacking, C..........Pawtucket, R. I.
Hackstaff, J. D...Los Angeles, Calif.
Hadaway, J. B........Boston, Mass.
Haddad, J..........Hartford, Conn.
Hadden, A. A..........Chicago, Ill.
Hadden, C. F.......New Orleans, La.
Hadley, F. L.....Pearl Harbor, T. H.
Hadley, R. W........Needham, Mass.
Hadley, S. A.......Kansas City, Mo.
Hadnot, L. R........Charlotte, N. C.
Haentjens, O..........Hazleton, Pa.
Haessler, W. M........Hampton, Va.
Hafer, G. P............Chicago, Ill.
Hafford, W. B......Davenport, Iowa.
Hagan, A. W......Bridgeport, Conn.
Hagar, A. P.......New York, N. Y.
Hagemann, G. E....New York, N. Y.
Hagen, J. F.......New York, N. Y.
Hagerman, O. S.........Chicago, Ill.
Hagerty, C. C.........Newark, N. J.
Hagerty, W. W.......Pottsville, Pa.
Haggerty, R. T..............
Richmond Hill, L. I., N. Y.
Haglund, A. G....Los Angeles, Calif.
Hagood, C. B., Jr.......Atlanta, Ga.
Hague, C. K. F........London, Eng.
Hague, D. L.........New York, N. Y.
Hague, H. O..........Chicago, Ill.
Hahn, A., Jr......E. Chicago, Ind.
Hahn, A. P.........Honolulu, T. H.
Hahn, C. A.........Pittsburgh, Pa.
Hahn, E..........New York, N. Y.
Hahn, H. P..........Paris, France
Hahn, P. L..........Frederica, Del.
Hahn, R. P........Kansas City, Mo.
Hahn, S. H............Akron, Ohio
Haight, H. V......Manchester, Eng.
Haile, W. A., Jr............
Campinas, Brazil, S. A.
Haines, D. O.......Hartford, Conn.
Haines, E. P.......Philadelphia, Pa.
Haislip, R. L........Maryville, Tenn.
Hake, R. A..........W. Lynn, Mass.
Haldeman, R. R......Trenton, N. J.
Halden, H. O......Kansas City, Mo.
Hale, A. B.............Tampa, Fla.
Hale, F. W.........Hartford, Conn.
Hale, G. A.........Stillwater, Okla.
Hale, R. S............Boston, Mass.
Hale, S. C.............Atlanta, Ga.
Haler, P. J.........Dagenham, Eng.
Hall, A. C.........W. Haven, Conn.
Hall, A. E. B.........Biddeford, Me.
Hall, A. G.........New York, N. Y.
Hall, C..............St. Louis, Mo.
Hall, E. L............Portland, Ore.
Hall, H................Beloit, Wis.
Hall, H. E..........Cambridge, Mass.
Hall, H. H.....Palisades Park, N. J.
Hall, H. S..........Hartford, Conn.
Hall, H. Y........New York, N. Y.
Hall, J. G.....Montreal, Que., Can.
Hall, J. M............Chicago, Ill.
Hall, J. R...........Hammond, Ind.
Hall, L. B..............Fargo, N. D.
Hall, L. G.............Chicago, Ill.
Hall, N. M......Winnipeg, Man., Can.
Hall, P. P-G.........Philadelphia, Pa.
Hall, R. Benson.....Hammond, Ind.
Hall, Roland B., Jr......Atlanta, Ga.
Hall, R. C......San Francisco, Calif.
Hall, R. D..........Harrison, N. J.
Hall, Ralph E........Pittsburgh, Pa.
Hall, Robt. Everett..New York, N. Y.
Hall, R. S...........Delmar, N. Y.
Hall, S. R...........Moscow, Idaho
Hall, W. A...........Boston, Mass.
Hall, W. G.........Honolulu, T. H.
Hall, Wm. M......New York, N. Y.
Hall, Willis M.....Waterbury, Conn.
Hall, W. S.........Brooklyn, N. Y.
Halladay, H. F....Watertown, N. Y.
Hallaman, C. G.........Dallas, Tex.
Hallanger, R. J....Alhambra, Calif.
Hallenbeck, G. E.......Toledo, Ohio
Haller, F., Jr..........Chicago, Ill.
Haller, H. E..........Pittsburgh, Pa.
Haller, K. R........Ridley Park, Pa.
Haller, L. G........Kingsport, Tenn.
Haller, O. J.........Pittsburgh, Pa.
Haller, R. V.....St. Augustine, Fla.
Hallett, S. G.....Washington, D. C.
Halliday, J. L..Oklahoma City, Okla.
Halliday, W. R......Hoboken, N. J.
Halliwell, A......Los Angeles, Calif.
Hallock, E. F......New York, N. Y.
Hallock, F. D.........Boston, Mass.
Hallock, H. F.........Oswego, N. Y.
Hallock, J. W.......Pittsburgh, Pa.
Halloran, R. A......Richmond, Calif.
Hally, G. H.....Toronto, Ont., Can.
Halperin, W.......New York, N. Y.
Halpern, B. M.....New York, N. Y.
Halpin, C. L..........Detroit, Mich.
Halpin, J. F..........Ansonia, Conn.
Halsey, W. D.........Hartford, Conn.
Ham, C. W............Urbana, Ill.
Hamblet, G. W......Lawrence, Mass.
Hambright, J. K......Millburn, N. J.
Hamel, C. G.......New York, N. Y.
Hamersley, C. S......Garfield, N. J.
Hamilton, A. S., Jr......Lynn, Mass.
Hamilton, C. B., Jr............
Toronto, Ont., Can.
Hamilton, D...........McLean, Va.
Hamilton, D. B.........Chicago, Ill.
Hamilton, D. T......Springfield, Vt.
Hamilton, J.........Washington, D. C.
Hamilton, J. R....Youngstown, Ohio
Hamilton, J. W.....Montclair, N. J.
Hamilton, K. D......Brockton, Mass.
Hamilton, R. I.......Palmyra, N. Y.
Hamilton, T. H.......Newark, N. J.
Hamilton, T. M.........Chicago, Ill.
Hamilton, W. B...Birmingham, Ala.
Hamilton, W. E....New York, N. Y.
Hamilton, W. F.....Simsbury, Conn.
Hamilton, W. I......Brooklyn, N. Y.
Hamilton, W. J.....Carbondale, Pa.
Hamlin, F........Phillipsburg, N. J.
Hamm, H. W.......Cincinnati, Ohio
Hammarstrom, E....New York, N. Y.
Hammell, R. H......Paulsboro, N. J.
Hammer, E. W......New York, N. Y.
Hammers, M. J.....New York, N. Y.
Hammerstein, H. K....St. Louis, Mo.
Hammerstrom, W. G..Lynchburg, Va.
Hammett, G. R.....New Orleans, La.
Hammett, H. G.........Troy, N. Y.
Hammett, P. M..............
Long Island City, N. Y.
Hammler, E.........Cincinnati, Ohio
Hammond, C. C.....New York, N. Y.
Hammond, E. K.........Chicago, Ill.
Hammond, E. S....Bloomfield, N. J.
Hammond, F. M..............
Bloomfield Hills, Mich.
Hammond, H. M.....Cleveland, Ohio
Hammond, H. S....New York, N. Y.
Hammond, J. S., Jr..New York, N. Y.
Hampton, F. W.......Glendale, Calif.
Hampton, L. N.....New York, N. Y.
Hamton, M...... ......Rye, N. Y.
Hanasek, F. J......New York, N. Y.
Hanauer, E. A....Hollis, L. I., N. Y.
Hanauer, S. L......New York, N. Y.
Handler, H...........Paterson, N. J.
Handloser, B. F......Pittsburgh, Pa.
Haney, G. E.........Columbus, Ohio
Haney, H. B.......Wilmington, Del.
Haney, J. W...........Lincoln, Neb.
Hanger, S. R.......Philadelphia, Pa.
Hanhart, H. E., Jr....Baltimore, Md.
Hanitz, H. T.........Rockford, Ill.
Hanke, W.........Dresden, Germany.
Hankison, L. E......Pittsburgh, Pa.
Hanks, G. R......High Bridge, N. J.
Hanley, C. D......New York, N. Y.
Hanley, W. A......Indianapolis, Ind.
Hannan, R. Q..............
W. New Brighton, S. I., N. Y.
Hannant, T. N..............
Long Island City, N. Y.
Hannewald, B......Indianapolis, Ind.
Hannold, J. R............Lititz, Pa.
Hannon, J. J.......Cleveland, Ohio
Hannum, C. M......Cleveland, Ohio
Hannum, J. E..........Chicago, Ill.
Hanny, R. M...........Lenape, Pa.
Hans, W. R..........Detroit, Mich.
Hanscom, W. W..San Francisco, Calif.
Hansel, H...........Dunellen, N. J.
Hansen, Alf...........Denver, Colo.
Hansen, Anton......New York, N. Y.
Hansen, Carl M..............
Rancagua, Chile, S. A.
Hansen, C. Magnus..............
Rancagua, Chile, S. A.
Hansen, E. H..Great Neck, L. I., N. Y.
Hansen, H. H..............
Central El Ejemplo, P. R.
Hansen, H. I.......Milwaukee, Wis.
Hansen, M..........Waterloo, Iowa.
Hansen, M. G. P....Brooklyn, N. Y.
Hansen, W. T......Bridgeport, Conn.
Hanson, A. E......Washington, D. C.
Hanson, E. L.........Cincinnati, Ohio
Hanson, F. P....San Francisco, Calif.
Hanson, H. C...........Trona, Calif.
Hanson, H. F......Wilkinsburg, Pa.
Hanson, K. P.........Baltimore, Md.
Hanson, L. C...........Hopewell, Va.
Hanson, M. E.......Haddonfield, N. J.
Hanson, R. F.........Detroit, Mich.
Hanssen, S. L..........Chicago, Ill.
Hansson, A. S......Västerås, Sweden.
Hanus, F. J..............
Buenos Aires, Argentina, S. A.
Hanzlik, H. J......Swarthmore, Pa.
Happel, A. W...........Toledo, Ohio
Harazim, S. J......New York, N. Y.
Harbeson, J. P., Jr....Camden, N. J.
Hardaway, W. D......Denver, Colo.
Hardgrave, J. C......Lubbock, Tex.
Hardgrove, R. M....New York, N. Y.
Hardie, P. H.........Brooklyn, N. Y.
Hardigg, J. C..............
Mathews Court House, Va.
Hardin, F. H..........New York, N. Y.
Harding, A.........New York, N. Y.
Harding, F. W..Mountain View, N. Y.
Harding, H...........Rochester, N. Y.
Harding, H. V......New York, N. Y.
Harding, L. A.........Buffalo, N. Y.
Harding, P. O......Wilmington, Del.
Hardy, G. F........New York, N. Y.
Hardy, J. A.........New York, N. Y.
Hardy, J. S.........San Jose, Calif.

Hardy, N. G............Dallas, Tex.
Hardy, R. J..........Rahway, N. J.
Hardy, W. A........New York, N. Y.
Hargens, F........Davenport, Iowa
Hargest, W. J........Brooklyn, N. Y.
Hargon, S............Houston, Tex.
Hargrave, R. W..Poughkeepsie, N. Y.
Harkins, H. D......Wilmington, Del.
Harlow, J. H......Philadelphia, Pa.
Harman, F. F..Elmhurst, L. I., N. Y.
Harman, G. A..........Arnold, Pa.
Harman, J. J......New York, N. Y.
Harman, W. H.....Philadelphia, Pa.
Harmer, J. G.....Philadelphia, Pa.
Harnsberger, A. E......Chicago, Ill.
Harp, T. L........Los Angeles, Calif.
Harper, A. C.......Wyomissing, Pa.
Harper, E. A...........Atlanta, Ga.
Harper, Edwin C........Peoria, Ill.
Harper, Ernest C.. ....Oil City, Pa.
Harper, J. H..........Chicago, Ill.
Harper, K. W......Cambridge, Mass.
Harper, P. S...........Chicago, Ill.
Harrigan, W.........New York, N. Y.
Harriman, N. F...Washington, D. C.
Harrington, A. E..Leominster, Mass.
Harrington, C. E.......Buffalo, N. Y.
Harrington, E. L....Pittsburgh, Pa.
Harrington, E. W..New York, N. Y.
Harrington, F. D..Washington, D. C.
Harrington, F. T......Detroit, Mich.
Harrington, G. G......Houston, Tex.
Harrington, J.........Riverside, Ill.
Harrington, J. L....Kansas City, Mo.
Harrington, R. P....Brooklyn, N. Y.
Harris, A. W.....Chattanooga, Tenn.
Harris, C. H.........Richmond, Va.
Harris, D. W.........Seattle, Wash.
Harris, E. N..........Seattle, Wash.
Harris, F. W......Los Angeles, Calif.
Harris, H. C......Philadelphia, Pa.
Harris, H. E......Bridgeport, Conn.
Harris, H. I........Brooklyn, N. Y.
Harris, H. P......Bridgeport, Conn.
Harris, H. S.......Philadelphia, Pa.
Harris, H. W..Flushing, L. I., N. Y.
Harris, L. B..........Trona, Calif.
Harris, M. W.......Brooklyn, N. Y.
Harris, P. B.....Los Angeles, Calif.
Harris, W. A..........Canton, Ohio
Harris, W. E............Tulsa, Okla.
Harris, W. J., Jr.......St. Louis, Mo.
Harrison, C. G........Detroit, Mich.
Harrison, Geo. G......Oakland, Calif.
Harrison, Gerald G..New York, N. Y.
Harrison, H........Philadelphia, Pa.
Harrison, J. H....Washington, D. C.
Harrison, J. L.......Haverford, Pa.
Harrison, R. E. W..Chambersburg, Pa.
Harrison, R. L....Washington, D. C.
Harschnek, R. A........Chicago, Ill.
Hart, C. F........New York, N. Y.
Hart, E. L...........Chicago, Ill.
Hart, F. M...........Buffalo, N. Y.
Hart, F. W..........Littleton, Colo.
Hart, G. B.......Kansas City, Kan.
Hart, H. P........Waterbury, Conn.
Hart, H. S.....New Britain, Conn.
Hart, L. H...........Sydney, Aust.
Hart, S. T..........Syracuse, N. Y.
Hartburg, H. L.........Denver, Colo.
Harteneberg, R. S.....Madison, Wis.
Harter, I., Jr......New York, N. Y.
Hartford, E........New York, N. Y.
Hartig, R. K.......Brooklyn, N. Y.
Hartin, F. R..........Maynard, Mass.
Hartkopf, H. A.........Union, N. J.
Hartley, H. D......Indianapolis, Ind.
Hartman, E. C.....Springfield, Ohio
Hartman, F. V..New Kensington, Pa.
Hartman, J. M.........Kewanee, Ill.
Hartman, L. G........Seattle, Wash.
Hartman, L. R.......Baltimore, Md.
Hartman, M. T., Jr..Gainesville, Fla.
Hartman, W...........Dayton, Ohio
Hartmann, C.........Cincinnati, Ohio
Hartshorn, D. S....Springfield, Mass.
Hartwell, A. E.........Houston, Tex.
Hartwell, H. B........Boston, Mass.
Hartwig, A.........New York, N. Y.
Harvey, A. H......Shanghai, China
Harvey, C. R......Philadelphia, Pa.
Harvey, E. E.........Buffalo, N. Y.
Harvey, J. C..........Boston, Mass.
Harvey, K. H......Glens Falls, N. Y.
Harvey, W. F......New York, N. Y.
Harza, L. F..........Chicago, Ill.
Hasbrouck, D. M...Jersey City, N. J.
Hasegawa, T.....San Francisco, Calif.
Haselberger, R.......Louisville, Ky.
Hashagen, J. B......Hoboken, N. J.
Hashimoto, S.......Yokohama, Japan
Haskell, B............Franklin, Pa.
Haskell, G. O.............Macon, Ga.
Haskell, J. D..........Fulton, N. Y.
Haskell, M. E........Bombay, India
Haskell, R........New York, N. Y.

Haskins, G. W....W. Lafayette, Ind.
Haslach, J. P......Plainfield, N. J.
Hasse, F. C............Chicago, Ill.
Hassell, H. J........Mammoth, Utah
Hassell, R. A....Elizabethport, N. J.
Hassler, F. R..........St. Louis, Mo.
Hassler, P. M...........Aurora, Ill.
Hassman, F. A......Cincinnati, Ohio
Hastings, A. Q.........Boulder, Colo.
Hastings, C. F..........Lynn, Mass.
Hastings, R. G........Boston, Mass.
Hatch, G. H........Danbury, Conn.
Hatch, T. F.........New York, N. Y.
Hateau, W..........Brooklyn, N. Y.
Hatheid, H. C..........Boston, Mass.
Hathaway, C. L........Miami, Ariz.
Hathaway, J. D..Montreal, Que., Can.
Hathaway, K....San Francisco, Calif.
Hathaway, L. B..New Bedford, Mass.
Hatheway, P. M......Brooklyn, N. Y.
Hatton, M..........New York, N. Y.
Hatzfeld, G., Jr..............
Great Neck, L. I., N. Y.
Hauck, E. J.........New York, N. Y.
Haug, J. S........Philadelphia, Pa.
Haughton, F. A...Schenectady, N. Y.
Haughton, H. O.......Hamden, Conn.
Haugse, V. S..........Fresno, Calif.
Hausel, W. M......New York, N. Y.
Hauser, G. H.................
Garden City, L. I., N. Y.
Hausman, M.........New York, N. Y.
Hausman, S.........Cedarhurst, Md.
Hausmann, L...........Chicago, Ill.
Hauswirth, W. G....New York, N. Y.
Hautau, L. A.........Detroit, Mich
Havemeyer, G. E....Brooklyn, N. Y.
Havemeyer, H. O., Jr...........
New York, N. Y.
Havens, K. B...Flushing, L. I., N. Y.
Haver, R. L.....San Fernando, Calif.
Hawes, A. W......Winchendon, Mass.
Hawke, C. E...Perth Amboy, N. J.
Hawkins, E. T......Brewster, N. Y.
Hawkins, G. A.....W. Lafayette, Ind.
Hawkins, G. W.....New York, N. Y.
Hawkins, R. R.........Chicago, Ill.
Hawks, A. S........Milwaukee, Wis.
Hawley, C. G........Cleveland, Ohio
Hawley, R. S......Ann Arbor, Mich.
Hawley, T...........Boston, Mass.
Hawley, W. P..........Chicago, Ill.
Hawn, R. J..........Birmingham, Ala.
Hay, B. W...........Detroit, Mich.
Hay, E. D...........Lawrence, Kan.
Hay, W. O., Jr.....New York, N. Y.
Haydock, J.........Plainfield, N. J.
Hayes, J. S.........Waltham, Mass.
Hayes, L. D....Morgantown, W. Va.
Hayes, L. W...........Boston, Mass.
Hayes, M. F......Middletown, Ohio
Hayes, P. R...........Augusta, Ga.
Hayes, W. T..............
Jackson Heights, L. I., N. Y.
Haynes, H........Greenwich, Conn.
Haynes, J. L...........Chicago, Ill.
Haynes, J. M......Mt. Pleasant, Mich.
Haynes, S. S.........Endicott, N. Y.
Haynes, W. E..Long Island City, N. Y.
Hays, F. N...........Munhall, Pa.
Hays, J. C.........New York, N. Y.
Hays, L. T..........Portland, Ore.
Hayward, J.........New York, N. Y.
Hazard, C. S..Long Island City, N. Y.
Hazard, G. C........St. Louis, Mo.
Hazelton, C. H.......Cleveland, Ohio
Hazelton, R. T......Cincinnati, Ohio
Hazen, D. S........Des Plaines, Ill.
Hazen, S. A........Maplewood, N. J.
Head, F...........New York, N. Y.
Headman, S..........Phœnix, Ariz.
Headrick, H. B.......St. Louis, Mo.
Heald, G. W...........Chicago, Ill.
Heald, R. H......Washington, D. C.
Heald, W. R.........Wilmington, Del.
Healey, E. A........New York, N. Y.
Healy, G. W........Munich, Germany
Healy, J. J.........Middletown, Ohio
Healy, J. M.........Brooklyn, N. Y.
Hearty, F. J....San Francisco, Calif.
Heath, D. P..........Detroit, Mich.
Heavilon, E. B......Cleveland, Ohio
Hebberd, L. L..........Chicago, Ill.
Hebden, F. S...........Peoria, Ill.
Hebert, M., Jr.....Port Arthur, Tex.
Hebler, W. O........Westfield, N. J.
Hebley, H. F..........Chicago, Ill.
Hechler, F. G......State College, Pa.
Heck, J. W.......Hollis, L. I., N. Y.
Heck, Robt. C. H.............
New Brunswick, N. J.
Heck, Robt. C. H., Jr........
New York, N. Y.
Hecker, A. E.......New York, N. Y.
Heckers, W........Glendale, W. Va.
Heckman, J. C.....New York, N. Y.
Heckman, L. E......Columbus, Ohio

Hedberg, H. F........Albany, N. Y.
Heddell, D........Los Angeles, Calif.
Hedges, S. E...Balboa Heights, C. Z.
Hedley, W. H....New Rochelle, N. Y.
Hedlind, W..........Estacada, Ore.
Hedrick, E. R....Los Angeles, Calif.
Heebink, B. G........Madison, Wis.
Heekin, D. M.......Cincinnati, Ohio
Heena, C. R........Cincinnati, Ohio
Heenan, J. N. D.......London, Eng.
Heffelfinger, H. B....Mendenhall, Pa.
Heffernan, J. T.......Seattle, Wash.
Heffernan, W. H.......Maynard, Mass.
Heftler, V. R.........Detroit, Mich.
Hegenbarth, F....Birmingham, Ala.
Heggem, C. O........Masillon, Ohio
Hehemann, F. H....Cincinnati, Ohio
Heichert, H. S.......Pittsburgh, Pa.
Heidenger, H. W....Indianapolis, Ind.
Heidenreich, E. L., Jr..........
Newburgh, N. Y.
Heidersbach, F.....New York, N. Y.
Heidinger, F..........Denver, Colo.
Heidloff, W. H......Cleveland, Ohio
Heikel, D. A...........Abo, Finland
Heilig, W...........Cincinnati, Ohio
Heilman, R. H......Pittsburgh, Pa.
Heimberger, G. J....Bayonne, N. J.
Heimberger, O. W...New York, N. Y.
Hein, E. A......Perth Amboy, N. J.
Heine, F. A............Reading, Pa.
Heine, G. H......Washington, D. C.
Heineman, J......Rutherford, N. J.
Heinen, F. C.......New York, N. Y.
Heintze, A. L........St. Louis, Mo.
Heinz, W. B......Bound Brook, N. J.
Heinze, Wm. Alex......Chicago, Ill.
Heinze, Wm. August.New York, N. Y.
Heinzelman, H. F.Astoria, L. I., N. Y.
Heise, L. W.........Milwaukee, Wis.
Heiser, G. H.......Philadelphia, Pa.
Heisler, F. W....Schenectady, N. Y.
Heitz, R. G.........Brooklyn, N. Y.
Heitz, R. L..................
Chuquicamata, Chile, S. A.
Helander, L........Manhattan, Kan.
Helbush, W. W..San Francisco, Calif.
Helfter, F. S..........Buffalo, N. Y.
Hella, R................Chicago, Ill.
Heller, E. W..........Newark, N. J.
Heller, F. C.........Barberton, Ohio
Heller, L. W......New York, N. Y.
Heller, M. M..........Austin, Tex.
Helmer, N. A.........Plainfield, N. J.
Helmer, R. L.......New York, N. Y.
Helmick, W. E....Los Angeles, Calif.
Helmrich, G. B.........Detroit, Mich.
Helmstaedter, W. E...Newark, N. J.
Helmstaedter, G. O....Newark, N. J.
Helpbringer, J. N....Cleveland, Ohio
Helquist, J. E........Newark, N. J.
Helt, W. C...........Omar, W. Va.
Heltzel, W. G..........Tulsa, Okla.
Helwig, A..........Brooklyn, N. Y.
Hem, E. S........New York, N. Y.
Hem, H. O.............Toledo, Ohio
Hember, I. M......Kansas City, Mo.
Hemenway, S. H....Philadelphia, Pa.
Hempel, H. W.........Belleville, Ill.
Hempstead, C. A......Milford, Conn.
Hemstreet, G. P..............
Hastings-on-Hudson, N. Y.
Hencky, H......Kharkov, U. S. S. R.
Hendersen, T. E........Chicago, Ill.
Henderson, C. L......Wichita, Kan.
Henderson, D......New York, N. Y.
Henderson, E. B.......Baltimore, Md.
Henderson, G.........Midland, Mich.
Henderson, G. T.....Charlotte, N. C.
Henderson, H........Pittsburgh, Pa.
Henderson, H. B....Marshfield, Ore.
Henderson, J........Brooklyn, N. Y.
Henderson, J. R...Swampscott, Mass.
Henderson, R. H....E. Orange, N. J.
Henderson, W. J..Toronto, Ont., Can.
Hendrich, H. A......Endicott, N. Y.
Hendrick, W. M..Mineola, L. I., N. Y.
Hendrickson, G. A....Detroit, Mich.
Hendrickson, G. S......Chicago, Ill.
Hendrickson, O......Ft. Peck, Mont.
Hendrie, C. F........Harrison, N. J.
Hengstler, J. L....Los Angeles, Calif.
Henkel, C. H........Pittsburgh, Pa.
Hennig, F. O.........Trenton, N. J.
Henning, C. F..........Chicago, Ill.
Henning, H. C..........St. Louis, Mo.
Henning, P. F.......Brooklyn, N. Y.
Henning, W. W........Chicago, Ill.
Hennings, W. C........Boston, Mass.
Henofer, J. P......New York, N. Y.
Henricksen, B.......New York, N. Y.
Henrickson, J. A.....Worcester, Mass.
Henrikson, W....Johnson City, N. Y.
Henry, A. S., Jr....New York, N. Y.
Henry, E. G..........Chicago, Ill.
Henry, F. D...........Albany, N. Y.
Henry, J. S......Castlemaine, Aust.

Henry, O. H........Brooklyn, N. Y.
Henry, S. L............Beloit, Wis.
Henry, W. M........New York, N. Y.
Hense, J. A........New York, N. Y.
Henseler, W. J....Weehawken, N. J.
Henshall, P. P....State College, Pa.
Henshaw, C. N.....Plattsburg, N. Y.
Henshaw, F........Scarsdale, N. Y.
Henshaw, F. V....New York, N. Y.
Henszey, J. W....State College, Pa.
Henszey, R. O.....Oconomowoc, Wis.
Henwood, J. B.....Bala-Cynwyd, Pa.
Henze, O. C. W....New York, N. Y.
Hepburn, J. W.........El Paso, Tex.
Hepke, W. C......Philadelphia, Pa.
Heppenheimer, H....New York, N. Y.
Heptinstall, W. G....Auckland, N. Z.
Hequembourg, J. E............
W. Caldwell, N. J.
Herb, C. O.........New York, N. Y.
Herbermann, C. G..Jersey City, N. J.
Herbert, C. G........Altadena, Calif.
Herbert, F. D......New York, N. Y.
Herbert, L. E.........Baltimore, Md.
Herbert, W. F........Houston, Tex.
Herbst, H. T...........Milford, Pa.
Herendeen, F. W......Geneva, N. Y.
Heres, R..............Newark, N. J.
Herley, R. J........Brooklyn, N. Y.
Herlinger, L. F.....New York, N. Y.
Herman, E. O......Cambridge, Mass.
Hernon, J. L.......New York, N. Y.
Herod, W. R..........London, Eng.
Heroux, L. H.........Plainfield, N. J.
Herpen, A. T.........Berlin, Germany
Herr, B. M..........Pittsburgh, Pa.
Herr, G. D...........Saylesville, R. I.
Herr, W. A.........Philadelphia, Pa.
Herr, W. H............Leonia, N. J.
Herreshoff, N. G........Bristol, R. I.
Herrick, C. A.....Minneapolis, Minn.
Herrick, D. A......Cambridge, Mass.
Herrick, E. P........Hartford, Conn.
Herrick, T. J....W. Lafayette, Ind.
Herrmann, J. F......Brooklyn, N. Y.
Herron, J. H........Cleveland, Ohio
Herron, W. L........Brooklyn, N. Y.
Hersam, C. O..........Atlanta, Ga.
Herschel, W. H....Washington, D. C.
Herschmann, A. J..New York, N. Y.
Hersee, F. C.......Cambridge, Mass.
Hersey, M. D......Philadelphia, Pa.
Hertel, C. C...........Berwick, Pa.
Hertslet, V. B......New York, N. Y.
Herty, F. B........Brooklyn, N. Y.
Hertzler, S. P.......Pittsburgh, Pa.
Herwegh, L. J......Philadelphia, Pa.
Hescheles, C. A......Brooklyn, N. Y.
Heslop, P. L.........Portland, Ore.
Hess, A. I..........Rochester, N. Y.
Hess, E. E............Lufkin, Tex.
Hess, J.......Long Island City, N. Y.
Hess, J. S..........New York, N. Y.
Hess, R. G...........Newark, N. J.
Hesse, A..Queens Village, L. I., N. Y.
Hesse, H. C.........University, Va.
Hesse, O. H.........New York, N. Y.
Hesselbach, C. F.....Elizabeth, N. J.
Hessellund, R...........Beloit, Wis.
Hester, E. G.......Willoughby, Ohio
Hetherington, C. F....St. Louis, Mo.
Hetherington, L. E...Cleveland, Ohio
Hetler, B. P.....Grand Rapids, Mich.
Hettinger, C.Hasbrouck Heights, N. J.
Hettrick, A. B......Piney River, Va.
Hettrick, G. D.....Fall River, Mass.
Hetzel, F. V.........W. Chester, Pa.
Hetzel, L. H......Bakerton, W. Va.
Hetzel, T. B..........Haverford, Pa.
Heumann, J. P.....New York, N. Y.
Heuser, H. V.........Louisville, Ky.
Hewitt, E. R........New York, N. Y
Hewitt, R. W.....Antwerp, Belgium
Heydecke, C. W.....Montclair, N. J.
Heyerdahl, T........Berlin, Germany
Heyl, E. B...........Irvington, N. Y.
Heyman, N. C.........Brooklyn, N. Y.
Heyman, S. N.........Detroit, Mich.
Heyward, T. C......Charlotte, N. C.
Hibbard, H. D.......Plainfield, N. J.
Hibbard, R. L........Pittsburgh, Pa.
Hibbard, T...........Milton, Mass.
Hickenlooper, S., Jr..Cincinnati, Ohio
Hickling, E. G......New York, N. Y.
Hickman, C. D......Philadelphia, Pa.
Hickman, H. B..S. Charleston, W. Va.
Hickox, C. M...S. Charleston, W. Va.
Hicks, G. C., Jr......La Jolla, Calif.
Hicks, J. R...........Hanover, N. H.
Hicks, K. M.........New York, N. Y.
Hicks, R. E.......Los Angeles, Calif.
Hider, G. T.....Lake Providence, La.
Hiebeler, H. G........Houston, Tex.
Hiers, G. O.........Brooklyn, N. Y.
Higbie, V............Paterson, N. J.
Higginbotham, O.........Perico, Cuba
Higgins, A.......Calgary, Alta., Can.

Higgins, A. C.......Worcester, Mass.
Higgins, E. M.....Watertown, Mass.
Higgins, G. F.........Melrose, Mass.
Higgins, J. E.........Chicago, Ill.
Higgins, J. W......Worcester, Mass.
Higgins, N. B........Baltimore, Md.
Higgins, Q. D.....Wilmington, Calif.
Higgins, T. J......New York, N. Y.
Higgins, W. J......New York, N. Y.
Higginson, E. E.........Chicago, Ill.
Higginson, T. H..Montreal, Que., Can.
Higley, F. R........Cleveland, Ohio
Hilands, W. H.......Pensacola, Fla.
Hilbert, C. D.......New York, N. Y.
Hilbert, W. M........Carteret, N. J.
Hildebrand, H. E....New York, N. Y.
Hildebrant, B. A....Worcester, Mass.
Hildenbrand, C. F....Baltimore, Md.
Hildreth, K. E.........Solvay, N. Y.
Hildreth, W. O......Syracuse, N. Y.
Hiles, E. K.........New York, N. Y.
Hilgartner, G. H......Richmond, Va.
Hill, A.........Glen Ferris, W. Va.
Hill, A. J.....Central Aguirre, P. R.
Hill, A. L............Denver, Colo.
Hill, C. H.........Philadelphia, Pa.
Hill, Ebenezer.......Stamford, Conn.
Hill, Ed...........Jonesboro, Ark.
Hill, E. G..........New York, N. Y.
Hill, E. K............Chicago, Ill.
Hill, E. R..........New York, N. Y.
Hill, F.............Wellford, S. C.
Hill, F. C..............Troy, N. Y.
Hill, G. B..........Ottumwa, Iowa
Hill, G. M..........Riverside, Calif.
Hill, H. D.............Dayton, Ohio
Hill, H. G.......Toronto, Ont., Can.
Hill, J. T..........Sugar Land, Tex.
Hill, M. F..........New York, N. Y.
Hill, R..............Detroit, Mich.
Hill, R. F.............Toledo, Ohio
Hill, R. J.............Chicago, Ill.
Hill, W...............Portland, Me.
Hill, W. H...........Trenton, N. J.
Hill, W. P......Sparrows Point, Md.
Hill, W. S.........Aberdeen, Wash.
Hillard, A. M.......Claremont, N. H.
Hille, E.....Long Island City, N. Y.
Hiller, J. L......Mattapoisett, Mass.
Hiller, M. L.......Frewsburg, N. Y.
Hiller, N. H.........Carbondale, Pa.
Hills, F. W.........New York, N. Y.
Hills, L. W.....San Francisco, Calif.
Hilmer, O. E.......Cincinnati, Ohio
Hilpert, M. G........Bethlehem, Pa.
Hilstrom, H. R....Bridgeport, Conn.
Hilton, B. LeR.....New York, N. Y.
Hilton, E. A..........Karachi, India
Himes, W. H.........Pittsburgh, Pa.
Hinchman, G. N..Webster Groves, Mo.
Hinckley, C. W.......Yonkers, N. Y.
Hinckley, W. C., Jr....Lowell, Mass.
Hindman, W. L.......Detroit, Mich.
Hine, R. C..........Baltimore, Md.
Hines, J. P.........Ft. Peck, Mont.
Hinkel, O. R.......New York, N. Y.
Hinman, L. R.........Denver, Colo.
Hinman, N. P........Buffalo, N. Y.
Hinrichs, E..........Fresnillo, Mex.
Hinshaw, M. W.......Alhambra, Calif.
Hinton, C. L., Jr..Phillipsburg, N. J.
Hinton, E. D.......Bronxville, N. Y.
Hires, J. E.......Philadelphia, Pa.
Hirsch, B. H....San Francisco, Calif.
Hirsch, C. E.........Billings, Mont.
Hirsch, G...........Columbus, Ohio
Hirsch, S. R........E. Orange, N. J.
Hirschberg, C. A..............
Mountain Lakes, N. J.
Hirschland, F. H....New York, N. Y.
Hirschman, W. F......Buffalo, N. Y.
Hirshfeld, C. F.........Detroit, Mich.
Hirth, E. F......Los Angeles, Calif.
Hitchcook, E. A......Columbus, Ohio
Hitchcock, J. H.....Worcester, Mass.
Hixon, C. R............Auburn, Ala.
Hjerpe, N. F.....New Britain, Conn.
Hoag, W. F.............Aurora, Ill.
Hoagland, C. N.....Bridgeport, Conn.
Hoagland, F. O......Hartford, Conn.
Hoagland, J. E.....Cambridge, Mass.
Hoar, J. C......New Kensington, Pa.
Hobart, F. G...........Beloit, Wis.
Hobart, H. M.....Schenectady, N. Y.
Hobart, J. C........Cincinnati, Ohio
Hobble, A. C.......Barcelona, Spain
Hobbs, E. E..........Annapolis, Md.
Hobbs, F. W..........Boston, Mass.
Hobbs, J. C........Painesville, Ohio
Hobbs, W. S.........Swarthmore, Pa.
Hobe, J. W..........Pittsburgh, Pa.
Hobein, K...Upper Montclair, N. J.
Hoberg, B. N........Spokane, Wash.
Hobson, R. B......Great Notch, N. J.
Hoch, F. W.........New York, N. Y.
Hoch, W. A.........New York, N. Y.
Hochman, J. L......Brooklyn, N. Y.

Hochuli, J. H...................
Richmond Hill, L. I., N. Y.
Hock, F. R..........Barberton, Ohio
Hockema, F. C....W. Lafayette, Ind.
Hodgart, H. M......Paisley, Scotland
Hodge, C. A..........Yonkers, N. Y.
Hodge, J. C...........Kearny, N. J.
Hodge, R. J......New Haven, Conn.
Hodges, J. L......Jersey City, N. J.
Hodges, K. R.......Davenport, Iowa
Hodges, M. E...Old Greenwich, Conn.
Hodgkinson, F......New York, N. Y.
Hodgkinson, G. A..Short Hills, N. J.
Hodgson, A. W..........Summit, N. J.
Hodson, W. D..........Chicago, Ill.
Hoe, R..........Poughkeepsie, N. Y.
Hoech, L. W......Coulee Dam, Wash.
Hoeckel, R. H......Shanghai, China
Hoefer, E. G.......Chapel Hill, N. C.
Hoehler, G. W......Upper Darby, Pa.
Hoerner, J. F......New York, N. Y.
Hoernes, H..........Columbus, Ind.
Hoevel, H. F.......New York, N. Y.
Hoey, C. R., Jr......Canton, N. C.
Hoffer, H. A.......Philadelphia, Pa.
Hoffhine, J..............Rye, N. Y.
Hoffman, A. A..........Trona, Calif.
Hoffman, C. E...........Donora, Pa.
Hoffman, D........Philadelphia, Pa.
Hoffman, G. A........St. Louis, Mo.
Hoffman, H. G......New York, N. Y.
Hoffman, H. L.........Denver, Colo.
Hoffman, H. T.........Cleveland, Ohio
Hoffman, J. D.....W. Lafayette, Ind.
Hoffman, J. E......New York, N. Y.
Hoffman, J. H..San Francisco, Calif.
Hoffman, J. R....Los Angeles, Calif.
Hoffman, P..............Easton, Pa.
Hoffman, R. C..........Detroit, Mich.
Hoffman, R. J......New York, N. Y.
Hoffman, R. N..Chañaral, Chile, S. A.
Hoffman, R. S........Bayonne, N. J.
Hoffman, W. C.........Chicago, Ill.
Hoffman, W. H......New York, N. Y.
Hoffmann, S...................
Scheveningen, Netherlands
Hoffner, C. M......Upper Darby, Pa.
Hofstetter, E. T. C....Baltimore, Md.
Hogan, C. L........San Carlos, P. I.
Hogan, J. P.........New York, N. Y.
Hogan, M. B....Salt Lake City, Utah
Hogan, P. H..........Boston, Mass.
Hoge, F. H............Chicago, Ill.
Hoge, W. W.........New York, N. Y.
Hogg, J. W........Upper Darby, Pa.
Hoglund, F. W.........Chicago, Ill.
Hohl, L. L...........Portland, Ore.
Hoke, A...............Cementon, Pa.
Holbrook, D. L.....New York, N. Y.
Holbrook, E. A.......Pittsburgh, Pa.
Holbrook, F. M........Kearny, N. J.
Holby, W. H.........New York, N. Y.
Holcomb, A. E......Milwaukee, Wis.
Holcomb, H. L.....Waterbury, Conn.
Holcombe, A. M...Washington, D. C.
Holden, C. M.........Boston, Mass.
Holden, P. E...Stanford Univ., Calif.
Holding, J. B.........Bayonne, N. J.
Hole, J. A..........New York, N. Y.
Holford, H. E....Binghamton, N. Y.
Holland, A. D..........Atlanta, Ga.
Holland, C. K......New York, N. Y.
Holland, F. W........Belleville, N. J.
Holland, U. C...New Brunswick, N. J.
Hollander, A........Berkeley, Calif.
Hollander, E.......Mt. Vernon, N. Y.
Holleman, H. I.........Miami, Fla.
Hollenbeck, G. K...........Erie, Pa.
Hollenberger, T. J......Chicago, Ill.
Holleran, D. J.........Newark, N. J.
Hollerith, H., Jr...Moorestown, N. J.
Hollerith, R.........Riverton, N. J.
Hollingsworth, L. C.....Atlanta, Ga.
Hollingsworth, S..Scotch Plains, N. J.
Hollingsworth, W. V.Zanesville, Ohio
Hollins, G. G.......New York, N. Y.
Hollis, E. A........New York, N. Y.
Hollis, H. D..........Marshall, Tex.
Hollis, R. F..............Alton, Ill.
Hollister, S. C........Ithaca, N. Y.
Hollopeter, E.......New York, N. Y.
Holloway, H. F......Montclair, N. J.
Holloway, W.........Gulfport, Miss.
Hollowell, J. S.....Jersey City, N. J.
Holly, L. F.......New York, N. Y.
Holm, L...........Versailles, Conn.
Holm, S. S.........New York, N. Y.
Holman, R. L.........Newport, Pa.
Holmberg, C. G.........Kearny, N. J.
Holmberg, E. O......Milwaukee, Wis.
Holmberg, J. C......Milwaukee, Wis.
Holmes, A. G., Jr...Fayetteville, Ark.
Holmes, C. W.........Haverford, Pa.
Holmes, G. R.......New Haven, Conn.
Holmes, H. W.........Detroit, Mich.
Holmes, J. A..........Chicago, Ill.

Holmes, J. T......Los Angeles, Calif.
Holmes, L. J.........Allentown, Pa.
Holmes, T. B.........Hartford, Conn.
Holmes, W. C.......Brooklyn, N. Y.
Holmested, D. S...Toronto, Ont., Can.
Holmquist, G. F......Bristol, Conn.
Holper, A. E...........Chicago, Ill.
Holt, D. R.........Goldsboro, N. C.
Holt, J............Cambridge, Mass.
Holt, J. H.........Wilmington, Del.
Holt, K. M.........W. Lynn, Mass.
Holt, R. G...........Leetonia, Ohio
Holt, W. G. H...Montreal, Que., Can.
Holtby, F........Minneapolis, Minn.
Holtgrewe, E. A.....Rochester, N. Y.
Holtman, K. S..........Akron, Ohio
Holton, A., Jr.......Norwood, Mass.
Holton, P. J., Jr....Providence, R. I.
Holtz, J. C.........Pittsburgh, Pa.
Holtzclaw, H. J...Washington, D. C.
Holtzman, P. T.......Baltimore, Md.
Holway, W. R...........Tulsa, Okla.
Holyoke, W. L.....Kingsport, Tenn.
Holzbaur, F. J......Kansas City, Mo.
Holzer, H. A.........Pittsburg, Kan.
Holzmacher, R. A..............
Richmond Hill, L. I., N .Y.
Homan, W. W.......Philadelphia, Pa.
Homewood, W. T...Wilmington, Del.
Homsher, R. L........W. Allis, Wis.
Honecker, N. C.........Boston, Mass.
Honiss, W. H....W. Hartford, Conn.
Honywill, A. W., Jr...Detroit, Mich.
Hood, B. B...........Trona, Calif.
Hood, O. P........Washington, D. C.
Hook, C. H...........Pittsburgh, Pa.
Hook, I. T...........Ansonia, Conn.
Hook, J. W.........New Haven, Conn.
Hook, W. H............Ithaca, N. Y.
Hooker, R. J...........Auburn, N. Y.
Hooker, T. F.......Rochester, N. Y.
Hooper, L. J........Worcester, Mass.
Hooper, R. P........Brooklyn, N. Y.
Hoopes, A. G....Los Angeles, Calif.
Hoopes, M...........Glens Falls, N. Y.
Hoopes, P. R.......Philadelphia, Pa.
Hoover, A. P.......Bronxville, N. Y.
Hoover, H..........Palo Alto, Calif.
Hoover, H. E..........Chicago, Ill.
Hope, E. S..........Saylesville, R. I.
Hope, R. DeV........Newark, N. J.
Hope, W. R........Wilmington, Del.
Hopf, A. R., Jr.....New York, N. Y.
Hopf, H. A.........New York, N. Y.
Hopkins, A. G..Maspeth, L. I., N. Y.
Hopkins, G. W., Jr.San Leandro, Calif.
Hopkins, H. R..........Suffolk, Va.
Hopkins, R. K.....Jersey City, N. J.
Hopkins, S. L........Ansonia, Conn.
Hopkins, W. E.........Boston, Mass.
Hopp, H..............Scranton, Pa.
Hopper, S. J.........Cincinnati, Ohio
Hopper, T. W........Suffern, N. Y.
Hoppes, J. J.......Springfield, Ohio
Hopping, E. L......Philadelphia, Pa.
Hopson, W. H.......New York, N. Y.
Hopton, W. E.........Syracuse, N. Y.
Hopwood, J. W......Pittsburgh, Pa.
Horan, N. E........Providence, R. I.
Horbund, I.........New York, N. Y.
Horger, O. J...........Canton, Ohio
Horigan, J. H..........Athol, Mass.
Hormann, F. R......New York, N. Y.
Hormell, D. C..........Chicago, Ill.
Horn, F..............London, Eng.
Horn, N. E.........New York, N. Y.
Horn, R. J......Poughkeepsie, N. Y.
Hornberger, F. C......Camden, N. J.
Horne, A. N.......Bartlesville, Okla.
Horne, G. A.........New York, N. Y.
Horne, J................Alcoa, Tenn.
Horne, J. A.........New York, N. Y.
Horne, J. P..........Corning, N. Y.
Horner, C. M.......E. St. Louis, Ill.
Horner, E. A.......New York, N. Y.
Horner, E. F..........Monroe, N. Y.
Hornschuch, H....Phillipsburg, N. J.
Horschman, R. L.......Tonopah, Nev.
Horsman, K. W......Harrison, N. J.
Horst, C. A...........Newton, Mass.
Horstmann, F. B.......Chicago, Ill.
Horton, A. J........New York, N. Y.
Horton, A. M..........Revere, Mass.
Horton, R. D.........Andover, N. J.
Horton, R. H.......Philadelphia, Pa.
Hosbein, L. H..........Chicago, Ill.
Hosford, Wm. F.....New York, N. Y.
Hosford, Wm. F................
Vancouver, B. C., Can.
Hosmer, A..........Charlotte, N. C.
Hosmer, S...........Boston, Mass.
Hossack, A. B.......New York, N. Y.
Hotchkiss, C. H. B...New York, N. Y.
Hottel, H. C........Cambridge, Mass.
Hottes, H. H...Grand Junction, Colo.
Hou, T. P..........Nanking, China

Hough, D. L........New York, N. Y.
Hough, W. F........New York, N. Y.
Houghton, B..........Brooklyn, N. Y.
Houghton, C. A.....Philadelphia, Pa.
Houghton, C. E.....New York, N. Y.
Houghton, C. R....Connersville, Ind.
Houghton, H. C......Bethlehem, Pa.
Houghton, H. S...Los Angeles, Calif.
Houghton, J. D.Pickwick Dam, Tenn.
Houghton, R. H......Detroit, Mich.
Houghton, W. M...Springfield, Mass.
Hould, G. F........Ft. Peck, Mont.
House, C. M............Chicago, Ill.
House, J. W....New Kensington, Pa.
Houser, A. M..........Chicago, Ill.
Houser, F. D.............Troy, Ohio
Houser, J. F...........Lebanon, Pa.
Housley, T. P......New York, N. Y.
Houstle, A. E., Jr...Rochester, N. Y.
Houston, A. J. R......Chicago, Ill.
Houston, G. H......Philadelphia, Pa.
Houston, H. A........Pittsburgh, Pa.
Houston, L. W.............Troy, N. Y.
Housum, C.........New York, N. Y.
Hovey, O. E.........New York, N. Y.
Hovgaard, W........Brooklyn, N. Y.
Howard, A. H...San Francisco, Calif.
Howard, C. D.......Swarthmore, Pa.
Howard, C. P.......Worcester, Mass.
Howard, E. E........Kansas City, Mo.
Howard, E. S.........St. Paul, Minn.
Howard, G. K........Brooklyn, N. Y.
Howard, H. S.........Oakland, Calif.
Howard, J. E..........Baltimore, Md.
Howard, K. S.........Eddystone, Pa.
Howard, O.....Oklahoma City, Okla.
Howard, T. W.....Schenectady, N. Y.
Howarth, E. S........Pittsburgh, Pa.
Howarth, H. A. S...Philadelphia, Pa.
Howarth, J. M.........Chicago, Ill.
Howe, A. W.....Poughkeepsie, N. Y.
Howe, C. S........N. Amherst, Mass.
Howe, E. D..........Berkeley, Calif.
Howe, E. W.......Providence, R. I.
Howe, F. J..........Pensacola, Fla.
Howe, J. A..........Riverside, N. J.
Howe, J. F.........Worcester, Mass.
Howe, J. L..........Cleveland, Ohio
Howell, A. K.........St. Louis, Mo.
Howell, F. B......New York, N. Y.
Howell, F. K.........Boonton, N. J.
Howell, H. W., Jr...New York, N. Y.
Howell, J. D.....S. Norwalk, Conn.
Howell, R. P., Jr.San Francisco, Calif.
Howell, R. S...........Atlanta, Ga.
Howell, S. S...........Chicago, Ill.
Howell, W. R.......Philadelphia, Pa.
Howes, R. V........New York, N. Y.
Howland, L. A...............
Far Rockaway, L. I., N. Y.
Howsam, H. C.........Chicago, Ill.
Howson, L. R..........Chicago, Ill.
Hoxie, G. L.....Los Angeles, Calif.
Hoxie, V. W....San Francisco, Calif.
Hoyer, C. O...........St. Louis, Mo.
Hoyer, W. A............Chicago, Ill.
Hoyt, A. J..........Worcester, Mass.
Hoyt, C. P.........Baton Rouge, La.
Hoyt, F. W..........Pittsburgh, Pa.
Hoyt, H. K.................Hull, Ill.
Hoyt, R. D...........Portland, Ore.
Hoyt, S. T..........Honolulu, T. H.
Hoyt, W. R........Philadelphia, Pa.
Hubbard, A. B.......E. Orange, N. J.
Hubbard, C. R........Palmyra, N. Y.
Hubbard, C. W.......Worcester, Mass.
Hubbard, G..........Cleveland, Ohio
Hubbard, G. W.....River Forest, Ill.
Hubbard, J. F.........Pittsburgh, Pa.
Hubbard, K. H.....Rochester, N. Y.
Hubbell, C. W..........Pittston, Pa.
Hubbell, G. W.......Barberton, Ohio
Hubbell, J. E.......New York, N. Y.
Hubbell, L. P..........Buffalo, N. Y.
Hubby, P. E.......New York, N. Y.
Huber, G. L.........Philadelphia, Pa.
Huber, J. S............Racine, Wis.
Hubert, D. G.........Yonkers, N. Y.
Hubley, G. W........Louisville, Ky.
Huck, W. F........New York, N. Y.
Hucka, D. J.......E. Pittsburgh, Pa.
Huckert, J. W......Rochester, N. Y.
Huckle, M. S..........Boston, Mass.
Hudson, A. H.......New York, N. Y.
Hudson, D. S.......New York, N. Y.
Hudson, E. B.......Middletown, Ohio
Hudson, E. L....Cabin Creek, W. Va.
Hudson, F. W....Toronto, Ont., Can.
Hudson, H. R...........Atlanta, Ga.
Hudson, R. M..........Boston, Mass.
Hudson, W. S.......Tenterden, Eng.
Huebner, W. C......New York, N. Y.
Huenger, O. A.........Whiting, Ind.
Huestis, H. E.....Quebec, Que., Can.
Huettl, W. A........Elizabeth, N. J.
Huey, J. S..........New Orleans, La.
Huff, G. F..........Pittsburgh, Pa.

Huffman, C. A......Longview, Wash.
Huffman, C. W................
Huntington Park, Calif.
Huffman, S. A.......Pittsburgh, Pa.
Hufford, J. D......Sweetwater, Tex.
Huge, E. C., Jr......Barberton, Ohio
Hugger, R...........Norwalk, Conn.
Hughes, A. D.........Portland, Ore.
Hughes, A. M....New York, N. Y.
Hughes, B. S.........Buffalo, N. Y.
Hughes, F. G.........Bristol, Conn.
Hughes, H. E.....New York, N. Y.
Hughes, J. H. J., Jr..Brooklyn, N. Y.
Hughes, J. S..........Buffalo, N. Y.
Hughes, M. B........Camino, Calif.
Hughes, M. I..........Trenton, N. J.
Hughes, R. G......Ridgewood, N. J.
Hughes, R. H.......New York, N. Y.
Hughes, R. M.........Detroit, Mich.
Hughey, A. H........Allentown, Pa.
Hugle, H...............Beloit, Wis.
Hugli, W. C., Jr.......Oradell, N. J.
Hugo, M. S.Stanford University, Calif.
Hulbert, C. S................
Harmon-on-Hudson, N. Y.
Hulbert, W. G..........Easton, Pa.
Hulbert, W. R.........Chicago, Ill.
Hulett, F. E..........Cleveland, Ohio
Hull, B. E............Houston, Tex.
Hull, E. H........Schenectady, N. Y.
Hull, J. L..........San Diego, Calif.
Hulse, G. E.........New Haven, Conn.
Hulsizer, R. L......Lock Haven, Pa.
Hulsman, H. W......Coronado, Calif.
Hulsmann, J. D......Brooklyn, N. Y.
Hulst, J...........New York, N. Y.
Hultan, K. A.......Filer City, Mich.
Hultin, R............Midland, Mich.
Humme, F. H......Wilmington, Del.
Hummel, J. G..........Ames, Iowa
Hummel, J. O. P...State College, Pa.
Hummel, R. A......New York, N. Y.
Humphrey, A. L.......Pittsburgh, Pa.
Humphrey, G. S..Staten Island, N. Y.
Humphreys, C. G...New York, N. Y.
Humphreys, W. H......Findlay, Ohio
Hundley, F. G...Bayside, L. I., N. Y.
Hungate, L. H., Jr....Memphis, Tenn.
Hungerford, W. H.......Chicago, Ill.
Hunsaker, J. C.....Cambridge, Mass.
Hunt, C. T..........Pittsburgh, Pa.
Hunt, E. E..........Riverside, Conn.
Hunt, F. B.............Chicago, Ill.
Hunt, H. S...........Jackson, Mich.
Hunt, J. E..........Philadelphia, Pa.
Hunt, N. C............Salem, Ohio
Hunt, P. N........Port Neches, Tex.
Hunt, R..............Savannah, Ga.
Hunt, S. P........Manchester, N. H.
Hunt, W. F...........Milford, Conn.
Hunt, W. P............Moline, Ill.
Huntar, F............Newark, N. J.
Hunter, A. T........Brooklyn, N. Y.
Hunter, C. F...........Elkhart, Ind.
Hunter, C. J..........Boston, Mass.
Hunter, C. W.......Philadelphia, Pa.
Hunter, E. E...Oklahoma City, Okla.
Hunter, E. L.......Knoxville, Tenn.
Hunter, G. E.............Elgin, Ill.
Hunter, J..........Winter Park, Fla.
Hunter, John A......Boulder, Colo.
Hunter, John A., Jr..Pittsburgh, Pa.
Hunter, John Alex....Pittsburgh, Pa.
Hunter, J. D........N. Adams, Mass.
Hunter, J. F......New York, N. Y.
Hunter, J. R...........Akron, Ohio
Hunter, J. W.........Brooklyn, N. Y.
Hunter, L. N........Johnstown, Pa.
Hunter, W. L............Erie, Pa.
Hunting, I. A.......New York, N. Y.
Huntoon, C. H., Jr.....Detroit, Mich.
Huntsberger, R. C.......Ashland, Ky.
Hupfel, A. G......New York, N. Y.
Hurlburt, R. B.......Brooklyn, N. Y.
Hurlburt, W. F., Jr..E. Orange, N. J.
Hurlock, C. E........Cleveland, Ohio
Hurrey, R. C.Great Kills, S. I., N. Y.
Hurst, J. F..........Louisville, Ky.
Hurst, S. A...........Leonia, N. J.
Hurt, R. M....................
Barranca-Bermeja, Colombia, S. A.
Hurt, W. C., Jr......Pittsfield, Mass.
Hurych, J. W....Astoria, L. I., N. Y.
Huson, W. S.........Brooklyn, N. Y.
Huss, H. O............Scranton, Pa.
Hussey, E. A......Burlington, N. J.
Hussey, T. O...................
Springfield Gardens, L. I., N. Y.
Hussey, W. E..Northport, L. I., N. Y.
Huster, R. A..........Chicago, Ill.
Huston, C. L.........Coatesville, Pa.
Hutchcraft, D. K........Tulsa, Okla.
Hutchens, R. W.....Eau Claire, Wis.
Hutchings, C. F.....New York, N. Y.
Hutchinson, A. H.......Atlanta, Ga.
Hutchinson, C. T....New York, N. Y.
Hutchinson, E. C...New York, N. Y.
Hutchinson, J. A.....Meriden, Conn.
Hutchinson, J. B...New York, N. Y.
Hutchinson, W. C.....Newton, Mass.
Hutchison, F. C....Kansas City, Mo.
Hutchison, F. P.......Orange, N. J.
Hutchison, M. R.....New York, N. Y.
Huthsteiner, R. E.....Allentown, Pa.
Hutsel, L. E.......Springfield, Ohio
Hutt, A. R........Thomaston, Conn.
Huttinger, W. R....Philadelphia, Pa.
Hutton, G. H..........London, Eng.
Hutton, S. E...........Seattle, Wash.
Huvane, J. F......New York, N. Y.
Huxford, G. T......Providence, R. I.
Huy, G. E.........New York, N. Y.
Huyser, F. C..........Rockford, Ill.
Hyde, G. C............Dallas, Tex.
Hyde, H. W.........Blacksburg, Va.
Hyde, J. P.........New York, N. Y.
Hyde, T. B.....Niagara Falls, N. Y.
Hyden, E. B., Jr..Chattanooga, Tenn.
Hyder, F. K........Maryville, Tenn.
Hyman, D............Buffalo, N. Y.
Hymans, F.........New York, N. Y.
Hynes, L. P........Philadelphia, Pa.

I

Iager, R. F.........New York, N. Y.
Ibser, H. P...........Detroit, Mich.
Iddles, A..........Philadelphia, Pa.
Idell, P. C............Boston, Mass.
Iglehart, R. L....Schenectady, N. Y.
Igleheart, G. P......Rockaway, N. J.
Iler, H. H..........Greenville, S. C.
Iliff, W. L...........Newark, N. J.
Illmer, L............Cortland, N. Y.
Illumin, M. V.........Oakland, Calif.
Imbembo, E. A.....New York, N. Y.
Imboden, C...........Detroit, Mich.
Imeson, C. V.......Jacksonville, Fla.
Impagliazzo, A. M....Massillon, Ohio
Imperial, F. F.........Manila, P. I.
Ims, E. C.................Erie, Pa.
Ingalls, C. H.............Lodi, N. J.
Ingalls, F. D. B........Boston, Mass.
Ingalls, R. I., Jr...Birmingham, Ala.
Ingham, H. S....Los Angeles, Calif.
Ingle, H. W.........Hartford, Conn.
Inglee, C...........New York, N. Y.
Ingles, J. S............Paducah, Ky.
Inglis, R. N........Westfield, N. J.
Inglish, H. C......E. Hartford, Conn.
Ingram, J. L............Tulsa, Okla.
Ingram, W. T..........Detroit, Mich.
Inman, E. R...........Franklin, Pa.
Inman, W. H..........Newark, N. Y.
Inman-Emery, J. I.....London, Eng.
Inslee, H. C........New York, N. Y.
Intemann, H. K.....New York, N. Y.
Inwright, J. A.........Kearny, N. J.
Iorillo, D. J.......Bridgeport, Conn.
Ireland, Mark L....New Orleans, La.
Ireland, Mark L., Jr............
Newport News, Va.
Ireland, T. H..........Chicago, Ill.
Ireland, W. F. A......Corning, N. Y.
Irey, G. W.............Joplin, Mo.
Irion, W.............Nutley, N. J.
Irmer, C. B........Philadelphia, Pa.
Irons, R. H..........Harrisburg, Pa.
Irvin, E. H..........Brooklyn, N. Y.
Irwin, D. B.........New York, N. Y.
Irwin, J. B..........Iowa City, Iowa
Irwin, J. W............Kearny, N. J.
Irwin, K. M.........Philadelphia, Pa.
Irwin, P. L.........New York, N. Y.
Irwin, R. R...........St. Louis, Mo.
Irwin, V. H..................
Buenos Aires, Argentina, S. A.
Isaacs, R. P........New York, N. Y.
Isaksen, R. C........Brooklyn, N. Y.
Ischinger, A. E.........Reading, Pa.
Iseman, J. W.......New York, N. Y.
Isenberg, M. H.Flushing, L. I., N. Y.
Isham, C. A........New York, N. Y.
Ishimura, L. S..........Kyoto, Japan
Isidin, B. J..........Cleveland, Ohio
Isles, F. W.............Linden, N. J.
Ivens, E. M.......New Orleans, La.
Ives, C. Q..............Reading, Mass.
Ives, G. S...........Stamford, Conn.
Ives, L. T..........New York, N. Y.
Ivory, H. V.......Jersey City, N. J.

J

Jabelmann, O..........Omaha, Neb.
Jack, C. R...........Portland, Ore.
Jack, G..............Lyndhurst, N. J.
Jacka, P. G......Chattanooga, Tenn.
Jacklin, H. M....W. Lafayette, Ind.
Jackson, A. A......New York, N. Y.
Jackson, A. C......Swarthmore, Pa.
Jackson, C. A......New York, N. Y.
Jackson, C. P., Jr..Birmingham, Ala.
Jackson, D. B........Seattle, Wash.
Jackson, D. C......Cambridge, Mass.
Jackson, D. C., Jr.......Chicago, Ill.
Jackson, F. R.......Charlotte, N. C.
Jackson, G. P......New York, N. Y.
Jackson, H. D.......Concord, N. H.
Jackson, H. O....Somersworth, N. H.
Jackson, H. W.........Lancaster, Pa.
Jackson, Jas. A...Schenectady, N. Y.
Jackson, Jesse A..Newport News, Va.
Jackson, J. B......New York, N. Y.
Jackson, J. P.......New York, N. Y.
Jackson, J. R........St. Louis, Mo.
Jackson, L. B...........Beloit, Wis.
Jackson, L. R........Louisville, Ky.
Jackson, P...........Louisville, Ky.
Jackson, R. E.......Yonkers, N. Y.
Jackson, R. O.............Rolla, Mo.
Jackson, W. G.......Harrison, N. J.
Jackson, W. H.....New York, N. Y.
Jacob, B. C.........Bay City, Mich.
Jacobi, E. B...........Akron, Ohio
Jacobi, N. E.......Milwaukee, Wis.
Jacobs, J. A.......Jersey City, N. J.
Jacobs, J. J., Jr........Buffalo, N. Y.
Jacobs, S. S...San Francisco, Calif.
Jacobs, W. M...Los Angeles, Calif.
Jacobs, W. S........Hartford, Conn.
Jacobsen, S. C..Salt Lake City, Utah
Jacobson, C. C.......Brooklyn, N. Y.
Jacobson, E. W......Pittsburgh, Pa.
Jacobson, F..Long Island City, N. Y.
Jacobson, S. B.......Elizabeth, N. J.
Jacobus, A. B....St. Johnsbury, Vt.
Jacobus, D. D.........Hoboken, N. J.
Jacobus, D. S......New York, N. Y.
Jacobus, R. F......New York, N. Y.
Jacoby, H. E.......New York, N. Y.
Jacques, S. A..........Chicago, Ill.
Jadrnicek, J. R..Cedar Rapids, Iowa
Jaecker, J. H...Huntington, W. Va.
Jaeger, U. R.........Syracuse, N. Y.
Jaeggli, H. R........Montclair, N. J.
Jagdmann, E. F........Chicago, Ill.
Jagientowicz, T. A....Harrison, N. J.
Jahn, E. A..Forest Hills, L. I., N. Y.
Jahncke, E. L......New Orleans, La.
Jahnke, C. B......Mt. Vernon, Ohio
Jakobsson, G. H...Washington, D. C.
Jakoby, A..College Point, L. I., N. Y.
Jakubovsky, J. H....Olympia, Wash.
James, G. D.........Chickasha, Okla.
James, J............New York, N. Y.
James, J. R..........Detroit, Mich.
James, R. F.....Poughkeepsie, N. Y.
James, W. A..........Buffalo, N. Y.
Jameson, J. A....Phillipsburg, N. J.
Jameson, S. L....Schenectady, N. Y.
Jamison, G. S....Glens Falls, N. Y.
Jamison, J. A.........Pittsburgh, Pa.
Janco, N.............Houston, Tex.
Janda, J. F.............Aurora, Ill.
Jandrisevits, P........Rahway, N. J.
Janes, C. H.........Gainesville, Fla.
Jannett, A. V., III....Huntsville, Ala.
Janousek, J..Long Island City, N. Y.
Janssen, E...........Pomona, Calif.
Janssen, H. J........Brooklyn, N. Y.
Jansson, J. H..........Newark, N. J.
Jansson, M. E....Washington, D. C.
Jansson, O. E......Philadelphia, Pa.
Japikse, B............Birdsboro, Pa.
Jappe, K. W.......New York, N. Y.
Jarcho, R...........Brooklyn, N. Y.
Jardh, W...........Inglewood, Calif.
Jardine, F..........Cleveland, Ohio
Jarecki, A.................Erie, Pa.
Jarema, J. D.................
Cartagena, Colombia, S. A.
Jarnagin, J. F..........Detroit, Mich.
Jaros, A. L., Jr....New York, N. Y.
Jaschka, J. H.........St. Louis, Mo.
Jasper, C. A.........Harrisburg, Pa.
Jasper, T. M.......Milwaukee, Wis.
Jauss, A. C........Wilmington, Del.
Jawitz, S...........New York, N. Y.
Jeffcott, R. C....Bound Brook, N. J.
Jefferies, F. L............Argo, Ill.
Jefferson, E. R.......Syracuse, N. Y.
Jeffery, E. I........Berkeley, Calif.
Jeffords, T. W........Detroit, Mich.
Jeffrey, R. H.........Columbus, Ohio
Jeffries, E............Oakmont, Pa.
Jeheber, R. A.........Swissvale, Pa.
Jehle, F.............Stamford, Conn.
Jenik, L. A........New York, N. Y.
Jenkins, E. N........Brooklyn, N. Y.
Jenkins, H. B.......New York, N. Y.
Jenkins, J. B......Ft. Worth, Tex.
Jenkins, P...........Yonkers, N. Y.
Jenkins, S..........Brooklyn, N. Y.
Jenkins, S. V...Niagara Falls, N. Y.
Jenks, F...........New York, N. Y.
Jenks, G. F.........Watertown, Mass.
Jenks, L. H........Rutherford, N. J.
Jenks, S. M.........Pittsburgh, Pa.
Jenks, W. H.........Brookville, Pa.
Jennes, A., Jr........Hoboken, N. J.
Jennings, B. H.......Bethlehem, Pa.
Jennings, C. H....E. Pittsburgh, Pa.
Jennings, I. C....So. Norwalk, Conn.
Jennings, W. A.....New York, N. Y.
Jens, A. H.............Chicago, Ill.
Jensen, E. W.......Rochester, N. Y.
Jensen, G. L............Norris, Tenn.
Jensen, J. A.......Philadelphia, Pa.
Jensen, J. O.....Coral Gables, Fla.
Jensen, J. W..........Chicago, Ill.
Jensen, M. A.......Springfield, Ohio
Jensen, S.......Los Angeles, Calif.
Jensen, S. R............Chicago, Ill.
Jensen, S. V...Copenhagen, Denmark
Jensen, W. F........Brooklyn, N. Y.
Jentsch, A. A..........Linden, N. J.
Jeppson, G. N......Worcester, Mass.
Jermy, L. E..........Cleveland, Ohio
Jervey, T. M......Springfield, Mass.
Jett, C. C..........Lexington, Ky.
Jett, G. C..........Milwaukee, Wis.
Jett, R. M..........Milwaukee, Wis.
Jetter, W..........Philadelphia, Pa.
Jewell, C. W..Ozone Park, L. I., N. Y.
Jewett, A. C........Pittsburgh, Pa.
Jewett, E. C.......Rochester, N. Y.
Jewett, F. B..........Boston, Mass.
Jewett, G. L.....W. Medford, Mass.
Jewett, W. R.........Passaic, N. J.
Jilek, O. F..........Appleton, Wis.
Jillson, O. A.........Detroit, Mich.
Jimerson, F. A..........Athens, Pa.
Joa, C. G.....Sheboygan Falls, Wis.
Joachim, W. F.......Annapolis, Md.
Jobin, F. J.........Plainfield, N. J.
Jobst, F. J........New York, N. Y.
Joerger, C. A.......Cincinnati, Ohio
John, E. T...........Effingham, Ill.
Johns, C. N..........Monessen, Pa.
Johnsen, B........New York, N. Y.
Johnsen, G. J.................
Caripito, Venezuela, S. A.
Johnson, A. C.....Downingtown, Pa.
Johnson, A. E....Washington, D. C.
Johnson, A. F.....Washington, D. C.
Johnson, A. J..........Primos, Pa.
Johnson, A. M........Rockford, Ill.
Johnson, A. P.....New York, N. Y.
Johnson, B. E........Rockford, Ill.
Johnson, B. J..........Detroit, Mich.
Johnson, B. M....Perth Amboy, N. J.
Johnson, B. S..........Chicago, Ill.
Johnson, C. A.........Erving, Mass.
Johnson, C. B.......Pittsburgh, Pa.
Johnson, C. C......Melbourne, Aust.
Johnson, C. G..........Chicago, Ill.
Johnson, C. L.....Charleston, W. Va.
Johnson, C. N......Ridgewood, N. J.
Johnson, C. O.........Savannah, Ga.
Johnson, C. R..........Chicago, Ill.
Johnson, C. V......Bloomfield, Conn.
Johnson, C. W........Amarillo, Tex.
Johnson, D. C......New York, N. Y.
Johnson, E. F., Jr..Haddonfield, N. J.
Johnson, E. G........Trenton, N. J.
Johnson, E. M.......St. Paul, Minn.
Johnson, E. T..........Chicago, Ill.
Johnson, Edw. William..Houston, Tex.
Johnson, Edw. Willis,
Waterbury, Conn.
Johnson, F. B........St. Louis, Mo.
Johnson, Francis E., Jr........
New York, N. Y.
Johnson, Fred E..Elizabethport, N. J.
Johnson, F. E. R......Hopewell, Va.
Johnson, F. V.........Baltimore, Md.
Johnson, G. A...........Chicago, Ill.
Johnson, G. L....Schenectady, N. Y.
Johnson, G. M.......Rochester, N. Y.
Johnson, G. T........Columbus, Ohio
Johnson, H........Baton Rouge, La.
Johnson, Harley A....Oak Park, Ill.
Johnson, Henry A., Jr..Fordwick, Va.
Johnson, Horace A..New York, N. Y.
Johnson, H. H.......New York, N. Y.
Johnson, H. K..Indian Orchard, Mass.
Johnson, Henry S..............
Babylon, L. I., N. Y.
Johnson, Hobart S.....Madison, Wis.
Johnson, Howard S...St. Paul, Minn.
Johnson, Herbert W..New York, N. Y.
Johnson, Howard W..New York, N. Y.
Johnson, J. Adolph....Louisville, Ky.
Johnson, Jos. A......Brooklyn, N. Y.
Johnson, Jos. Benj..Los Angeles, Calif.
Johnson, Jos. Blaine..Springfield, Vt.
Johnson, J. F........Belleville, N. J.
Johnson, J. M........Bayonne, N. J.
Johnson, J. O.....Washington, D. C.
Johnson, J. P..........Dallas, Tex.
Johnson, J. Roland.....Fullerton, Pa.
Johnson, John R......Rockford, Ill.
Johnson, J. W......New York, N. Y.
Johnson, K. S......Phillipsdale, R. I.

Johnson, L. M..........Chicago, Ill.
Johnson, L. T.......Cleveland, Ohio
Johnson, L. V.......McKeesport, Pa.
Johnson, L. W......Amesbury, Mass.
Johnson, M. G....Mt. Vernon, N. Y.
Johnson, M. M......New York, N. Y.
Johnson, P. A....Jewett City, Conn.
Johnson, P. F........Altadena, Calif.
Johnson, P. G........Seattle, Wash.
Johnson, R.........New York, N. Y.
Johnson, R. B......Honolulu, T. H.
Johnson, R. D.....New York, N. Y.
Johnson, Roy E....New York, N. Y.
Johnson, Ruben E..Bremerton, Wash.
Johnson, T. S................
Kew Gardens, L. I., N. Y.
Johnson, T. W......Annapolis, Md.
Johnson, T. W., Jr..Philadelphia, Pa.
Johnson, Warren....New Orleans, La.
Johnson, Werner........Miami, Fla.
Johnson, W. A......New York, N. Y.
Johnson, W. E......Ft. Wayne, Ind.
Johnson, W. G.........Moline, Ill.
Johnson, W. H........Detroit, Mich.
Johnson, W. L........Alliance, Neb.
Johnson, W. W........W. Lynn, Mass.
Johnston, E. G..Niagara Falls, N. Y.
Johnston, E. W.....Rochester, N. Y.
Johnston, G. X.......St. Clair, Mich.
Johnston, J. A.........Richmond, Va.
Johnston, K. M........London, Eng.
Johnston, L.........New York, N. Y.
Johnston, L. C..Niagara Falls, N. Y.
Johnston, L. M...........Parco, Wyo.
Johnston, P. K.......Cincinnati, Ohio
Johnston, R. K........Milford, Mich.
Johnston, R. S........Trenton, N. J.
Johnston, W. A....Cambridge, Mass.
Johnston, W. S......New York, N. Y.
Johnstone, C. A......Seattle, Wash.
Jolly, T. D..........Pittsburgh, Pa.
Jonasson, C. W.......Spokane, Wash.
Jones, A.............Lancaster, Pa.
Jones, A. I.........Rochester, N. Y.
Jones, A. T......Toronto, Ont., Can.
Jones, B...........New York, N. Y.
Jones, C. C........Philadelphia, Pa.
Jones, C. L...New Philadelphia, Ohio
Jones, C. R....Morgantown, W. Va.
Jones, C. W........Columbus, Ohio
Jones, D. J.............Chicago, Ill.
Jones, D. T..........Pottstown, Pa.
Jones, E. E.........N. Adams, Mass.
Jones, Edw. H......Clearwater, Fla.
Jones, Edwin Hiram...........
Nazareth, Pa.
Jones, E. S..........Honolulu, T. H.
Jones, F. A...........Bristol, Tenn.
Jones, F. C........Drexel Hill, Pa.
Jones, F. R........Fitchburg, Mass.
Jones, H. C..........Scranton, Pa.
Jones, H. L......Glen Ridge, N. J.
Jones, H. R............Pulaski, Va.
Jones, H. R. E.........Dallas, Tex.
Jones, J. B..........Blacksburg, Va.
Jones, Jas. D.....Youngstown, Ohio
Jones, J. Delbert........Tulsa, Okla.
Jones, J. E.............Chicago, Ill.
Jones, John G......Rochester, N. Y.
Jones, John Gething..Columbus, Ohio
Jones, J. P...........Avenal, Calif.
Jones, K............Corvallis, Ore.
Jones, K. A., Jr......Wharton, Tex.
Jones, K. E.........Longview, Tex.
Jones, L..........Youngstown, Ohio
Jones, Leon B..San Francisco, Calif.
Jones, Lloyd B......Columbus, Ohio
Jones, M. D..........Allentown, Pa.
Jones, M. M..............York, Pa.
Jones, M. W.......Providence, R. I.
Jones, R. C........New York, N. Y.
Jones, R. E........Birmingham, Ala.
Jones, Robt. R.........Chicago, Ill.
Jones, Robt. Rollin.....Akron, Ohio
Jones, S. B........Piedmont, W. Va.
Jones, W. A..................
Port Richmond, S. I., N. Y.
Jones, W. B....San Francisco, Calif.
Jones, W. F..........Newark, N. J.
Jonge, A. E. R. de..New York, N. Y.
Joost, G. E..........Portland, Ore.
Jordan, L. T..................
Maracaibo, Venezuela, S. A.
Jordan, W. A.......New York, N. Y.
Jorgensen, P. E....Philadelphia, Pa.
Jorgensen, W..........Camden, N. J.
Jory, R..........New York, N. Y.
Joseph, P. A.....Los Angeles, Calif.
Josepho, A. M.Pacific Palisades, Calif.
Josephs, L. C., Jr....Allentown, Pa.
Joslyn, R. O........Kansas City, Mo.
Jourdin, W. W......Shanghai, China
Jowett, E..........Kansas City, Mo.
Joy, F. A...........Newport, N. H.
Joy, J............New York, N. Y.
Joyce, C. S........New York, N. Y.
Joyce, H. B...............Erie, Pa.
Joyce, R.........Washington, N. J.
Juchtern, C. D......New York, N. Y.
Judd, H............Columbus, Ohio
Jude, H............New York, N. Y.
Judkins, M. F.......McKeesport, Pa.
Judson, C. F.......New York, N. Y.
Judson, H. H.......Brooklyn, N. Y.
Judy, W. H..................
Buenos Aires, Argentina, S. A.
Juelss, D............Hoboken, N. J.
Julian, M. D........Lake Forest, Ill.
Julius, M. A....Haarlem, Netherlands
Jullien, A............Newark, N. J.
Julsrud, R. S..........Croton, N. Y.
Jung, A. H.........Brooklyn, N. Y.
Junghans, A. E......Lancaster, Pa.
Junghans, E. K........Ponce, P. R.
Junker, A. J.......Cambridge, Mass.
Juram, W. C., Jr...Philadelphia, Pa.
Jurgens, E. G..........Chicago, Ill.
Jurgensen, C. A......Trenton, N. J.
Justice, F. C...........Dallas, Tex.
Justice, W. C........Baltimore, Md.
Justus, J. E............Beloit, Wis.

K

Kabakjian, E. J....Philadelphia, Pa.
Kabili, M. M.......New York, N. Y.
Kabis, C. W..........Newark, N. J.
Kaddeland, C. R....New York, N. Y.
Kaderly, J. M......Knoxville, Tenn.
Kaemmerling, G. H........Erie, Pa.
Kaempffert, W......New York, N. Y.
Kaernekull, C. O..Stockholm, Sweden
Kaestner, P. T....White Plains, N. Y.
Kaeufler, C. W. V......St. Louis, Mo.
Kahle, L. F.Caripito, Venezuela, S. A.
Kahlenberg, R. W....Two Rivers, Wis.
Kahn, B. B..........Hamilton, Ohio
Kahn, H..........New York, N. Y.
Kahn, J............Cleveland, Ohio
Kahn, J. M............Atlanta, Ga.
Kahn, L..........New York, N. Y.
Kahrs, H. G..................
Valley Stream, L. I., N. Y.
Kahrs, O..............Oslo, Norway
Kaier, R........Elizabethport, N. J.
Kain, E. M..........Barberton, Ohio
Kaiser, E. R.........Columbus, Ohio
Kales, W. R......River Rouge, Mich.
Kaley, G. B........New York, N. Y.
Kalkhuis, F. W.....New York, N. Y.
Kalmbach, F........New York, N. Y.
Kammerhoff, M......Magnolia, N. J.
Kamo, M...............Tokyo, Japan
Kampish, N. S....Roselle Park, N. J.
Kane, E. J............Chicago, Ill.
Kanik, R. M......Monte Vista, Colo.
Kantrow, M. W.....New York, N. Y.
Kao, S. C.........Chengchow, China
Kaprelian, E......Washington, D. C.
Karassik, I. J.......New York, N. Y.
Karekin, Y. M......New York, N. Y.
Karelitz, G. B.....New York, N. Y.
Karg, W. E.........Burlington, N. J.
Karl, W. C............Detroit, Mich.
Karle, J. D......Elizabethport, N. J.
Karlson, C. B......New York, N. Y.
Karlson, K. W........Racine, Wis.
Karlsson, H........Wellsville, N. Y.
Karlsson, R..........Oak Park, Ill.
Karlsten, A. R.......Spokane, Wash.
Karmazin, J........Grosse Ile, Mich.
Karnasch, L. M..San Francisco, Calif.
Karp, R. E.........Knoxville, Tenn.
Karpov, A. V........Pittsburgh, Pa.
Karr, I. C............Sterling, Ill.
Karre, W. A....Niagara Falls, N. Y.
Karsel, E...............Chicago, Ill.
Karsunky, W. K...Washington, D. C.
Kartinen, E.......Coulee Dam, Wash.
Kasameyer, W. E..Terre Haute, Ind.
Kaser, A. J..........Cleveland, Ohio
Kassander, A. R....New York, N. Y.
Kassebohm, W. H..Emeryville, Calif.
Kassner, P. A......Irvington, N. J.
Katcher, M........New York, N. Y.
Kates, E. J........New York, N. Y.
Kato, Y..........Kure City, Japan
Katow, M. S......Los Angeles, Calif.
Kattelle, L. W......New York, N. Y.
Katzenberger, G. B..Greenville, Ohio
Katzenstein, M. L..New York, N. Y.
Kauffman, H. L..Schenectady, N. Y.
Kauffman, H. P........Boston, Mass.
Kauffman, S. H....Philadelphia, Pa.
Kauffmann, W. M......Buffalo, N. Y.
Kaufman, A. R.....Philadelphia, Pa.
Kaufman, M..........Bloomfield, N. J.
Kavanaugh, W. H..Philadelphia, Pa.
Kaven, M. B........Worcester, Mass.
Kaveny, T., Jr.......Pittsburgh, Pa.
Kay, L. D...........Alhambra, Calif.
Kay, R. H............Seattle, Wash.
Kayan, C. F........New York, N. Y.
Kaye, J. W......W. Orange, N. J.
Kaylor, J. H.......Wheeling, W. Va.
Kayser, W. H.....New York, N. Y.
Keables, A. D........Catskill, N. Y.
Keane, A. F..........Hopewell, Va.
Kearney, T. J........Detroit, Mich.
Kearns, B. A........Cincinnati, Ohio
Kearns, C. M.....E. Hartford, Conn.
Keating, A. E......Providence, R. I.
Keating, D. A......Bridgeport, Conn.
Keating, T. E....New York, N. Y.
Keator, F. W......New Haven, Conn.
Keay, A. E.............Nutley, N. J.
Keck, P. U.........Pittsburgh, Pa.
Kedy, S. F..........Melrose, Mass.
Keefe, D. C........New York, N. Y.
Keeler, H. E......Ann Arbor, Mich.
Keeler, J. F.......New York, N. Y.
Keeley, W. C., Jr....New York, N. Y.
Keen, G. W...........Baltimore, Md.
Keenan, J. H......Cambridge, Mass.
Keenan, J. S............Selby, Calif.
Keenan, Walter F., Jr..........
New York, N. Y.
Keenan, Walter Francis, 3rd....
Charleston, W. Va.
Keenan, W. M......New York, N. Y.
Keene, B. F......Philadelphia, Pa.
Keene, J. A..........Newark, N. J.
Keener, H. J..Flushing, L. I., N. Y.
Keese, R. B......Los Angeles, Calif.
Keesing, M........New York, N. Y.
Keeth, G..........Rothschild, Wis.
Keeth, J. A........Kansas City, Mo.
Keever, H. K........Stamford, Conn.
Kehl, R. J........New York, N. Y.
Kehoe, D. E..........Savannah, Ga.
Keifer, B. E........Cincinnati, Ohio
Keil, E. F............Buffalo, N. Y.
Keim, C. J.............Dallas, Tex.
Keiser, A. C., Jr........Atlanta, Ga.
Keiser, R. D..........Buffalo, N. Y.
Keisker, A. P........Savannah, Ga.
Keith, J. H......Sacramento, Calif.
Keith, R. R..........Racine, Wis.
Keith, R. W..........Ithaca, N. Y.
Kellenberger, C. D., Jr........
Greensboro, N. C.
Keller, A. T.........Bethlehem, Pa.
Keller, A. W.......New York, N. Y.
Keller, E..........New York, N. Y.
Keller, E. E......Birmingham, Mich.
Keller, F. J..Long Island City, N. Y.
Keller, G. H........Aruba, D. W. I.
Keller, G. J........Iowa City, Iowa
Keller, H. H........Jenkintown, Pa.
Keller, H. R......Zurich, Switzerland
Keller, J. F........New York, N. Y.
Keller, J. M........Berkeley, Calif.
Keller, K. T..........Detroit, Mich.
Keller, L. F........Cleveland, Ohio
Keller, M. W..........Oneida, N. Y.
Keller, R. D........Hartford, Conn.
Keller, R. L........Winthrop, Mass.
Keller, W. D..........Alliance, Ohio
Keller, W. H..........St. Louis, Mo.
Kelley, E. F..........Boston, Mass.
Kelley, F. W., Jr......Berlin, N. H.
Kelley, R. T..........Butte, Mont.
Kellogg, A. S..........Boston, Mass.
Kellogg, C. McM......St. Louis, Mo.
Kellogg, C. W........Allegan, Mich.
Kellogg, H. F..........Chicago, Ill.
Kellogg, M. W......New York, N. Y.
Kellogg, R. M......New York, N. Y.
Kellogg, W. D....Amsterdam, N. Y.
Kelly, E. M.............Troy, Ohio
Kelly, E. R.........Waltham, Mass.
Kelly, H. J..........Pittsburgh, Pa.
Kelly, J. P.........Pittsfield, Mass.
Kelly, J. T..................
Glenwood Landing, L. I., N. Y.
Kelly, P. M.........Plainfield, N. J.
Kelly, T. C.........Cincinnati, Ohio
Kelly, T. E........Philadelphia, Pa.
Kelly, T. J............Shannon, Ga.
Kelsey, G. W.......New York, N. Y.
Kelsey, H. D.......Bloomfield, N. J.
Kelsey, J. G.......Waterbury, Conn.
Kelsey, W. H........Stockton, Utah
Kemler, E..............Tulsa, Okla.
Kemmer, A. J......New York, N. Y.
Kemmer, P. H..........Dayton, Ohio
Kemmish, L. W......Spokane, Wash.
Kemp, H. A.......Washington, D. C.
Kemp, L. W......Perth Amboy, N. J.
Kemp, W. V. A......Clayton, N. Y.
Kendall, E. E...........Salem, Ohio
Kendall, E. H.........Alliance, Ohio
Kendall, H. Clayton.Worcester, Mass.
Kendall, Howard C......Azusa, Calif.
Kendall, M. A...........Aurora, Ill.
Kende, G...........New York, N. Y.
Kending, E. K..Flushing, L. I., N. Y.
Kendrick, J. F.........Chicago, Ill.
Kenerson, W. H....Providence, R. I.
Kenley, B. E.......San Angelo, Tex.
Kennaugh, J. P.......Detroit, Mich.
Kennedy, A. M......University, Ala.
Kennedy, C. A......Harrison, N. J.
Kennedy, D. P. ....Barahona, D. R.
Kennedy, E. V. N.............
Montreal, Que., Can.
Kennedy, G. S......Brookline, Mass.
Kennedy, H. T......New York, N. Y.
Kennedy, J. C.........Elmira, N. Y.
Kennedy, J. E..........Manila, P. I.
Kennedy, J. S......New York, N. Y.
Kennedy, M. E.........Elmira, N. Y.
Kennedy, P. S........Newark, N. J.
Kennedy, R. E.........Chicago, Ill.
Kennedy, S. G........Lakeland, Fla.
Kennedy, W. A.....Providence, R. I.
Kennedy, W. C..........Alcoa, Tenn.
Kennedy, W. M......Hoboken, N. J.
Kennedy, W. P.....New York, N. Y.
Kenney, J. T.......Pittsburg, Calif.
Kenney, L. H......Philadelphia, Pa.
Kent, C. H.......State College, Pa.
Kent, F. J.........New York, N. Y.
Kent, H. R....Upper Montclair, N. J.
Kent, H. S........Birmingham, Ala.
Kent, L. R..........Baltimore, Md.
Kent, N. W............Chicago, Ill.
Kent, R. H......Clifton Heights, Pa.
Kent, R. S..........Brooklyn, N. Y.
Kent, R. T...........Verona, N. J.
Kent, R. W.........New York, N. Y.
Kent, S. L., Jr......Philadelphia, Pa.
Kentis, G. E., Jr.....Cleveland, Ohio
Kenward, S. B................
Bay Shore, L. I., N. Y.
Kenyon, J. M......Accrington, Eng.
Kenyon, V. L., Jr..Greensboro, N. C.
Kenyon, W. R......Woonsocket, R. I.
Keowen, R. T......New York, N. Y.
Kepler, D. A.......Maplewood, N. J.
Keplinger, C. H.........Tulsa, Okla.
Keppel, H. B., Jr.............
Flushing, L. I., N. Y.
Keppler, P. W.......Scarsdale, N. Y.
Kerbey, E. A.......New York, N. Y.
Kerchner, C. E.....Greensboro, N. C.
Kerins, J. S.......New York, N. Y.
Kerker, H. F..........Buffalo, N. Y.
Kermer, M. J..........Buffalo, N. Y.
Kern, J. F., Jr.Elmhurst, L. I., N. Y.
Kerner, L. C........New York, N. Y.
Kerr, A. J.............Tulsa, Okla.
Kerr, C. P........Washington, D. C.
Kerr, C. V.......Los Angeles, Calif.
Kerr, E...........Downingtown, Pa.
Kerr, E. W.........Baton Rouge, La.
Kerr, G. W..........Johnstown, Pa.
Kerr, H. H............Toledo, Ohio
Kerr, H. J.........New York, N. Y.
Kerr, H. K......Toronto, Ont., Can.
Kerr, J.............Elizabeth, N. J.
Kerr, R. L., Jr.....Philadelphia, Pa.
Kerr, S. L.........Philadelphia, Pa.
Kerr, T. H..........Columbus, Ohio
Kerr, W. E........Youngstown, Ohio
Kerzel, A..........Hood River, Ore.
Kessler, A. G.........Buffalo, N. Y.
Kessler, H. H......Philadelphia, Pa.
Kessler, H. R......New York, N. Y.
Kessler, J. R.......Philadelphia, Pa.
Ketcham, H. H......Bethlehem, Pa.
Ketchpel, P. A....Bergenfield, N. J.
Ketchum, S...........Newark, N. J.
Kettering, C. F.......Detroit, Mich.
Keuffel, A. W.......Montclair, N. J.
Keuffel, C. W........Hoboken, N. J.
Kevorkian, G. R.......Malden, Mass.
Key, F...............St. Louis, Mo.
Keyes, F. H...........Boston, Mass.
Keyes, H. M...........Buffalo, N. Y.
Keyes, J. H............Tulsa, Okla.
Keyes, S. N..Amherstberg, Ont., Can.
Keys, D. L.........New York, N. Y.
Keys, W. C...........Detroit, Mich.
Khiralla, T. W........Woburn, Mass.
Khosla, R. K.........Calcutta, India
Khrennikoff, G. V...Philadelphia, Pa.
Kibbe, H. E....W. Springfield, Mass.
Kidd, A..........Jersey City, N. J.
Kidd, G. F.........E. Orange, N. J.
Kidde, W..........New York, N. Y.
Kidder, W. E............Troy, N. Y.
Kiefer, C. J........Cincinnati, Ohio
Kiefer, P. E.........Cleveland, Ohio
Kiefer, P. J..........Annapolis, Md.
Kiehl, E. P........Philadelphia, Pa.
Kiehnle, W. A......New York, N. Y.
Kiernan, F. R...Flushing, L. I., N. Y.
Kiesel, J. S........Williamsport, Pa.
Kiesel, W. F., Jr..Hollidaysburg, Pa.
Kieselbach, H. A....New York, N. Y.
Kiesewetter, F. H....Covington, Ky.
Kiesling, T. S........Waterloo, Iowa
Kiester, H. T........Alameda, Calif.
Kiewit, A. L....Columbia Park, Ohio
Kihn, W. J...........Boston, Mass.
Kilbourne, H. G...Georgetown, Mass.

Kildebo, H. M......Somerville, N. J.
Kilgore, R. G...........Akron, Ohio
Killam, H. G.......Saylesville, R. I.
Killinger, C. E....Panama City, Fla.
Kimball, A. L....Schenectady, N. Y.
Kimball, C......Cape Girardeau, Mo.
Kimball, Dexter S.....Ithaca, N. Y.
Kimball, Dexter S., Jr...Akron, Ohio
Kimball, H. B........Beverly, Mass.
Kimball, I. D.......Fitchburg, Mass.
Kimball, J. L..........Salem, Mass.
Kimball, R. S.........Oakland, Calif.
Kimball, R. W.........Chicago, Ill.
Kimber, H. A....New Rochelle, N. Y.
Kimberlin, P. H...Youngstown, Ohio
Kimbrough, G. C., Jr.Memphis, Tenn.
Kimmel, A. W..........Dayton, Ohio
Kincade, E. C.........Houston, Tex.
Kincaid, R. M........Adelaide, Aust.
Kindermann, W. J..Mt. Vernon, N. Y.
Kindig, A. J..........Mishawaka, Ind.
King, C................Palmer, Mass.
King, C. B.......Los Angeles, Calif.
King, C. G. Y..........Evanston, Ill.
King, D. M..........Waltham, Mass.
King, D. W.........New York, N. Y.
King, E. R...........Allentown, Pa.
King, F. A...........Springfield, Ill.
King, F. J..........New York, N. Y.
King, G. I..........New York, N. Y.
King, H. F........Cambridge, Mass.
King, H. M..........W. Lynn, Mass.
King, John A.......Worcester, Mass.
King, John Aubrey....Lawrence, Kan.
King, J. B..........Milwaukee, Wis.
King, J. J.............Houston, Tex.
King, K. J..........Terre Haute, Ind.
King, M. A............Jeannette, Pa.
King, N. M........New York, N. Y.
King, P. M.......Los Angeles, Calif.
King, R. M.........Stuttgart, Ark.
King, R. S..............Atlanta, Ga.
King, V. C..........Worcester, Mass.
King, W. V..........Brooklyn, N. Y.
Kingman, D. G....Los Angeles, Calif.
Kingsbury, A.......Philadelphia, Pa.
Kingsbury, H. J...Kalamazoo, Mich.
Kingsbury, J. G....Fall Brook, Calif.
Kingsbury, R. W...Jacksonville, Fla.
Kingsley, W. H....W. Orange, N. J.
Kinkead, R. E........Cleveland, Ohio
Kinnard, J. A...........Detroit, Mich.
Kinne, C. E.........Watertown, N. Y.
Kinney, A. M.........Cincinnati, Ohio
Kinney, J. N.........Brooklyn, N. Y.
Kinney, T. S....San Francisco, Calif.
Kinney, W. F..........Detroit, Mich.
Kinnison, C. J.........Alameda, Calif.
Kinraide, R..........Westwood, Mass.
Kinsey, A. S..........Hoboken, N. J.
Kinsinger, H. B.....Cincinnati, Ohio
Kinsman R. E..........Elmira, N. Y.
Kinter, D. W...San Francisco, Calif.
Kiplinger, C. G.......Buffalo, N. Y.
Kipp, L...................Alton, Ill.
Kipp, T.......Winnipeg, Man., Can.
Kirby, J. F., Jr.Jamaica, L. I., N. Y.
Kirby, W. C............Atlanta, Ga.
Kirby, W. K.......Los Angeles, Calif.
Kirgan, J. F.....Phillipsburg, N. J.
Kirk, De N. B......Forest Grove, Pa.
Kirk, G. L...................Elgin, Ill.
Kirkby, T. M.........Green Bay, Wis.
Kirkpatrick, A.....Philadelphia, Pa.
Kirkpatrick, F. M..........Erie, Pa.
Kirkup, J. P.................
Port Washington, L. I., N. Y.
Kirkwood, A. C....Kansas City, Mo.
Kirloskar, S. L..Kirloskarvadi, India
Kirsch, C. R......Waterbury, Conn.
Kirsch, C. W..........Toledo, Ohio
Kirsten, F. K.........Seattle, Wash.
Kirwan, K. K., Jr....Baltimore, Md.
Kiser, L.................Toledo, Ohio
Kish, P. L..............Chicago, Ill.
Kishbaugh, T. L...Los Angeles, Calif.
Kissam, W. M.......Wyoming, N. J.
Kistler, N. L...........Hopewell, Va.
Kistler, P. N.......Providence, R. I.
Kite, H. J...........Philadelphia, Pa.
Kiteley, W. J...Bayside, L. I., N. Y.
Kitt, S................Brooklyn, N. Y.
Kittredge, B. L...........Oil City, Pa.
Kittredge, J. M......Paterson, N. J.
Kittredge, J. W.....New York, N. Y.
Kittredge, S. W.....New York, N. Y.
Kivlin, A. P......N. Attleboro, Mass.
Kjelsberg, H. A...............
Winterthur, Switzerland
Klaas, G. P.......Temple City, Calif.
Klafstad, E...........Belmont, Mass.
Klappenbach, H. E...Milwaukee, Wis.
Klarfelt, K.............Oslo, Norway
Klauber, L. M.......San Diego, Calif.
Klauder, L. T......Philadelphia, Pa.
Klaus, L. J...Long Island City, N. Y.
Klees A. L.........New York, N. Y.
Kleffel, H. E.......New York, N. Y.
Klein, A. C...........Boston, Mass.
Klein, A. W.........Bethlehem, Pa.
Klein, B. A.........New York, N. Y.
Klein, B. D...Long Island City, N. Y.
Klein, E. W............Atlanta, Ga.
Klein, J. A.............Lebanon, Pa.
Klein, J. J.........Dorchester, Mass.
Klein, O. K.....Magdeburg, Germany
Klein, P. M..............Easton, Pa.
Klein, R...........Montclair, N. J.
Kleinman, H. A.........Moline, Ill.
Kleinman, O.......New York, N. Y.
Kleinschmidt, K.......Clifton, N. J.
Kleinschmidt, R. V..Stoneham, Mass.
Klemin, A.........New York, N. Y.
Klep, M. C............Nyack, N. Y.
Klessig, E. F.........Detroit, Mich.
Kligfield, G.........Brooklyn, N. Y.
Kligman, A. R.Indian Orchard, Mass.
Klinck, J. H......E. Pittsburgh, Pa.
Kline, J. LeR..........Reading, Pa.
Kline, L. A........Youngstown, Ohio
Kline, M. E.....San Francisco, Calif.
Kline, P. A............Canton, Ohio
Klinedinst, L. M.......Canton, Ohio
Kling, F. E.......Youngstown, Ohio
Klinksiek, K..........St. Louis, Mo.
Klintman, P. C..............
Cartagena, Colombia, S. A.
Klise, R. E.....Grand Rapids, Mich.
Klock, E. L.......La Romana, D. R.
Klopp, C. G..........Canton, N. C.
Klosson, M. M..N. Tonawanda, N. Y.
Klotz, E. L.........New York, N. Y.
Klotz, H. J............Boston, Mass.
Kluesener, H. H.....Newark, N. J.
Klumpp, J. B.......Philadelphia, Pa.
Klutey, F. E.......Wilmington, Del.
Knabe, F. S.....Sparrows Point, Md.
Knapp, E. C.....Schenectady, N. Y.
Knapp, L. G...........Dayton, Ohio
Knapp, R. T........Pasadena, Calif.
Knapp, V. W........New York, N. Y.
Knapp, W............Lancaster, Pa.
Knapp, W. E..........Evanston, Ill.
Knauer, E............Detroit, Mich.
Knezo, J., Jr.....Jersey City, N. J.
Knibbe, K............Detroit, Mich.
Knickerbacker, J....Waterford, N. Y.
Kniese, H. G............Peoria, Ill.
Kniflin, L. F.........Brooklyn, N. Y.
Knight, A. W.........Beacon, N. Y.
Knight, E. R.......Providence, R. I.
Knight, G. L.......Brooklyn, N. Y.
Knight, J. E.........Baltimore, Md.
Knight, S..........Cambridge, Mass.
Knight, S. H.......Philadelphia, Pa.
Knipe, R. K.......Philadelphia, Pa.
Knipping, R. H.........Austin, Tex.
Knisely, E. S........Bethlehem, Pa.
Kniskern, W. H.......Hopewell, Va.
Knoblock, A. F........Detroit, Mich.
Knocke, L. T.........Detroit, Mich.
Knodel, C. G........Richmond, Va.
Knoedler, E. L., Jr..New York, N. Y.
Knoll, H...........Tallahassee, Fla.
Knoll, R. J...........St. Louis, Mo.
Knoop, T. M.........Harrison, N. J.
Knorr, E. L...........Covina, Calif.
Knott, F. W..........Savannah, Ga.
Knott, M. J..........Bristol, Conn.
Knowles, C. T.......Cleveland, Ohio
Knowles, R. C......Brooklyn, N. Y.
Knowlton, F. K.....Rochester, N. Y.
Knowlton, P. H., Jr............
Schenectady, N. Y.
Knox, J. R.......Newport, Scotland
Knox, S. L. G......Englewood, N. J.
Knox, W...............Urbana, Ill.
Knudsen, K. V................
Buenos Aires, Argentina, S. A.
Knudson, M. C........Houston, Tex.
Koch, B. F.Hastings-on-Hudson, N. Y.
Koch, C...........Philadelphia, Pa.
Koch, E. G...........Miranda, Cuba
Koch, G. B.............Altoona, Pa.
Koch, G. W....Jamaica, L. I., N. Y.
Koch, H. G.........Plainfield, N. J.
Koch, Robt. A........Pitman, N. J.
Kocher, E. H.........Boonton, N. J.
Kocher, E. J...San Bernardino, Calif.
Kocsis, J............Pittsburgh, Pa.
Koefoed, T...........Detroit, Mich.
Koehler, C. L......Cincinnati, Ohio
Koehler, R. H.......Cleveland, Ohio
Koenig, A. C........Lancaster, Ohio
Koenig, E. C...........Chicago, Ill.
Koenig, E. H......Weehawken, N. J.
Koenig, F. E....New Brunswick, N. J.
Koenig, L. R...........St. Louis, Mo.
Koepke, C. A......Minneapolis, Minn.
Koeppel, C. H.....Hackensack, N. J.
Koerper, E. C..........Chicago, Ill.
Koester, H.........Waterbury, Conn.
Koffskey, G........New Orleans, La.
Kohl, F. S........Swampscott, Mass.
Kohler, A. J........Brooklyn, N. Y.
Kohler, A. M.......New York, N. Y.
Kohler, J. H......Cambridge, Mass.
Kohler, L. F.........Brooklyn, N. Y.
Kohlmann, G......New York, N. Y.
Kohn, E. J.............Ensley, Ala.
Kohut, F. J.......Philadelphia, Pa.
Kolb, R. P.........Worcester, Mass.
Kolbe, R. E.........Honolulu, T. H.
Kollas, W. J.........Portland, Ore.
Kollberg, G. L......Milwaukee, Wis.
Kolmes, M. G......Brooklyn, N. Y.
Kolmorgen, E. L......Yonkers, N. Y.
Kölsch, O ......Mannheim, Germany
Konheim, H. S.....New York, N. Y.
Koons, G. I........Philadelphia, Pa.
Koontz, D. L..........Denver, Colo.
Koontz, L. B......Washington, D. C.
Kopeck, W. W......New York, N. Y.
Koper, F. G........New York, N. Y.
Kopf, E. A......Elizabethport, N. J.
Kopf, J. L..........New York, N. Y.
Kopf, W. F.........Elizabeth, N. J.
Koplin, R. D.......Philadelphia, Pa.
Korb, F. B............Chicago, Ill.
Korf, O. A........Washington, Iowa
Korff, F. H.........New York, N. Y.
Korff, H. H............Chicago, Ill.
Korn, N. L............Ashland, Ky.
Kornfeld, A. E......New York, N. Y.
Korte, R. B...........Roanoke, Va.
Kortgard, F. H.....New York, N. Y.
Koskinen, E. T......Hamilton, Ohio
Kotcher, E............Dayton, Ohio
Kothe, O. W..........St. Louis, Mo.
Kothny, G. L......Philadelphia, Pa.
Kotilinek, J............Chicago, Ill.
Kotzebue, M. H.........Tulsa, Okla.
Kountz, C. M.......Morro Bay, Calif.
Kousmin, S....Leningrad, U. S. S. R.
Kouwenhoven, F. W...Baltimore, Md.
Kovach, A. J.........Rochester, Pa.
Kowal, W. J........Worcester, Mass.
Kowaleski, Wm. C...Green Bay, Wis.
Kowalski, E...........Passaic, N. J.
Kozacka, J. S..........Chicago, Ill.
Kozak, H...........Cleveland, Ohio
Kozbelt, L. S......Mt. Pleasant, Pa.
Kraft, L. L...........St. Louis, Mo.
Kraft, O. H.........Milwaukee, Wis.
Kramer, A. A.......Kansas City, Mo.
Kramer, C...........Baltimore, Md.
Kramer, C. W............Atlanta, Ga.
Kramer, D. F.........Detroit, Mich.
Kramer, H. K......New York, N. Y.
Kramer, R. L.....Temple City, Calif.
Kramlich, C. W.....Milwaukee, Wis.
Kranich, H. O.........Toledo, Ohio
Krannert, H. C.....Indianapolis, Ind.
Kranz, W. G.........Cleveland, Ohio
Kraps, L. J.......Long Beach, Calif.
Kratsch, A. E.......Manitowoc, Wis.
Kratz, A. P.............Urbana, Ill.
Kratz, R. P.........Pasadena, Calif.
Kratzer, J. C.........Buffalo, N. Y.
Kraujalis, F. S.........Chicago, Ill.
Kraus, C..............Rockford, Ill.
Kraus, C. E........Springfield, Ohio
Kraus, J., Jr...........Chicago, Ill.
Kraus, M. N........New York, N. Y.
Krause, K. H.Marmol, Argentina, S. A.
Krause, R.............Chicago, Ill.
Krause, R. M..St. George, S. I., N. Y.
Krauss, A. H.......New York, N. Y.
Kraut, C. R......Berne, Switzerland
Kraut, H. B.......Fon du Lac, Wis.
Krebs, F. J........New York, N. Y.
Krebs, H. J..........Detroit, Mich.
Kregar, S. W.......Belleville, N. J.
Krehbiel, F. A.........Chicago, Ill.
Kreher, E..............Tampa, Fla.
Kreidler, D. W.......Detroit, Mich.
Kreisinger, H.......New York, N. Y.
Kreitzman, W. F.....Valparaiso, Ind.
Krejci, E. L..........Hammond, Ill.
Kremer, W. R.......Milwaukee, Wis.
Kremser, A......San Francisco, Calif.
Kresser, L.........Springfield, Mass.
Krichbaum, W. F.....Newark, N. J.
Krider, H. R.........Pittsburgh, Pa.
Krider, R. M...San Francisco, Calif.
Krieg, E. H........New York, N. Y.
Krieg, J. L.........New York, N. Y.
Kriegh, G. W.........Ontario, Calif.
Kriegsheim, H......New York, N. Y.
Kriek, P. P....... ....Enka, N. C.
Krinner, L..........New York, N. Y.
Krishnamurthy, B. S...........
Bhadravati, India
Kristo, F. J.......Jersey City, N. J.
Kritzman, S. A........Boston, Mass.
Kroes, L. C........New York, N. Y.
Krogmann, F. X...Washington, D. C.
Krol, P. F..........Bayonne, N. J.
Kroll, L. A.........Brooklyn, N. Y.
Krolle, S. L........New York, N. Y.
Kromer, A. P...Rosedale, L. I., N. Y.
Kromer, W. F........Pittsburgh, Pa.
Kroner, E. F...........Norfolk, Va.
Kroon, R. P........Philadelphia, Pa.
Krooss, J..........New York N. Y.
Kropp, R............Houston, Tex.
Kropp, R. F.Whitestone, L. I., N. Y.
Kroto, G........New Rochelle, N. Y.
Krotoff, E. G...Leningrad, U. S. S. R.
Kroupsky, V.......New York, N. Y.
Krueger, F. J.......New York, N. Y.
Krueger, G. H........Seattle, Wash.
Krueger, H. F........Oak Park, Ill.
Krueger, J. W......Milwaukee, Wis.
Kruger, L. R...San Francisco, Calif.
Kruger, P. F...Santiago, Chile, S. A.
Kruger, S. J. P.....New York, N. Y.
Krugman, J.........Brooklyn, N. Y.
Krummel, L. C...............
Brightwaters, L. I., N. Y.
Kruse, L. F........Maplewood, N. J.
Krysin, J. A........Greenfield, Mass.
Kuba, G...........Philadelphia, Pa.
Kuc, A............Philadelphia, Pa.
Kuchler, T. C......Sharon Hill, Pa.
Kuck, K. T.....New Knoxville, Ohio
Kueck, E. J........Pine Bluff, Ark.
Kuehn, H. R...........Chicago, Ill.
Kuehn, K. F..........Clifton, N. J.
Kuempel, L. L..........Atlanta, Ga.
Kuen, W. E.........Drexel Hill, Pa.
Kuenzel, C. J....Grand Rapids, Mich.
Kuenzel, H...........St. Louis, Mo.
Kugel, H. K......Washington, D. C.
Kugler, A. N......Ridgewood, N. J.
Kuhlen, F.........New York, N. Y.
Kuhn, A. R.........Brooklyn, N. Y.
Kuhn, E. W.........Barberton, Ohio
Kuhn, G. W........Brooklyn, N. Y.
Kuhnow, B. F. L....New York, N. Y.
Kukowitz, L. J.Elmhurst, L. I., N. Y.
Kuldell, R. C.........Houston, Tex.
Kulick, S..........Brooklyn, N. Y.
Kuljian, H. A......Philadelphia, Pa.
Kullmer, F......San Francisco, Calif.
Kumming, E..........St. Louis, Mo.
Kunkel, G. M........Lewisburg, Pa.
Kunz, W. J........New York, N. Y.
Kupfer, R. C......Los Angeles, Calif.
Kupferle, E...........St. Louis, Mo.
Kupfrian, W. J...............
Hasbrouck Heights, N. J.
Kuppenheimer, J. D.New York, N. Y.
Kurganoff, A.......New York, N. Y.
Kurilla, J............Bayonne, N. J.
Kuriloff, A. H.....Los Angeles, Calif.
Kurkjian, A. S...Grand Rapids, Mich.
Kurrein, M..........Haifa, Palestine
Kurth, C. H...........St. Louis, Mo.
Kurtz, J. V......Toronto, Ont., Can.
Kurzina, S. B., Jr.....Elmira, N. Y.
Kushman, J. C........Newark, N. J.
Kushnick, W. H...............
Long Island City, N. Y.
Kusnierek, C. J................
International Falls, Minn.
Kusold, C.........New York, N. Y.
Kuthe, C. H..........Wooster, Ohio
Kutter, H. L........Hamilton, Ohio
Kutter, R. L........Hamilton, Ohio
Kuttler, J. B.........Newark, N. J.
Kutzleb, R. Jr.,.....Brooklyn, N. Y.
Kuwada, G.........Hiogo-ken, Japan
Kuylenstjerna, A.......Narberth, Pa.
Kveton, N. J...........Chicago, Ill.
Kwang, K. Y........Tientsin, China
Kyburz, W. W..........Chicago, Ill.
Kylin, H. O.........Cleveland, Ohio

L

Laabs, E. H.........Milwaukee, Wis.
Labarre, R. V.....Los Angeles, Calif.
LaBoulais, J.......New York, N. Y.
Labounsky, N......New York, N. Y.
LaBreque, R. J.Acton Vale, Que., Can.
Lacazette, A. A.....New York, N. Y.
Lacchia, J. F.........Detroit, Mich.
Lachnicht, G. H., Jr.New York, N. Y.
LaCroix, A. J.....Southbridge, Mass.
LaCrosse, E...........Boston, Mass.
Lacy, R............Shade Gap, Pa.
Ladd, G. H........Indianapolis, Ind.
Ladd, G. T..........Pittsburgh, Pa.
Laemle, M. M..St. Gallen, Switzerland
LaFave, L. V.......Cleveland, Ohio
La Fetra, C. W................
Long Island City, N. Y.
La Fetra, H. L......New York, N. Y.
Lafferty E. C.......Springfield, Ohio
Lafore, J. A.........Philadelphia, Pa.
LaForge, R. M......Knoxville, Tenn.
Laftman, R. N.....Wilmington, Del.
Lager, C. A....Baldwinsville, N. Y.
Lahens, C. E. B....Philadelphia, Pa.
Lahy, D. O.....Babylon, L. I., N. Y.

Laiming, H. J..........Yeadon, Pa.
Laine, L..........Richmond, Calif.
Laird, A. W.......Watertown, N. Y.
Laird, I. L...........Walpole, Mass.
Laitmon, J..........Brooklyn, N. Y.
Lake, S..............Milford, Conn.
Lakey, A. B.......Philadelphia, Pa.
Lamache, A........New York, N. Y.
Lamack, A. H........St. Louis, Mo.
Lamb, H. M...........Saltville, Va.
Lamb, J. F........New York, N. Y.
Lambelet, C. H.....Hoboken, N. J.
Lambert, C. F.........Miami, Fla.
Lambert, F. M........Narberth, Pa.
Lambert, J. L......New York, N. Y.
Lambert, S. M......New York, N. Y.
Lamberti, H. V.....New York, N. Y.
Lambertine, J. A....Brooklyn, N. Y.
Lamborn, J. P......Philadelphia, Pa.
Lamont, N. C.........Ambridge, Pa.
La Motte, W. R.....Newark, N. J.
Lancaon, J. S.......Somerville, Mass.
Lancaster, K. G........Topeka, Kan.
Land, C. B..Long Island City, N. Y.
Landes, H. D...Salt Lake City, Utah
Landfear, G. H.......Bayonne, N. J.
Landgraf, G. F........Lebanon, Pa.
Landis, J. N........Brooklyn, N. Y.
Landis, L. H.....Mechanicsburg, Pa.
Landis, M. H........Waynesboro, Pa.
Landis, R. P.........Harrisburg, Pa.
Landvoight, T. E........Miami, Fla.
Lane, A. A..........Pittsburgh, Pa.
Lane, A. H.......Warrensburg, N. Y.
Lane, F. H............Chicago, Ill.
Lane, H. G..........Norwalk, Conn.
Lane, H. M.........Grosse Ile, Mich.
Lane, R. K.............Tulsa, Okla.
Lane, R. S.........New York, N. Y.
Lane, W. T............Chicago, Ill.
Laney, F. R........Stamford, Conn.
Lang, A. G......San Francisco, Calif.
Lang, H. W.........New York, N. Y.
Lang, J.......Salt Lake City, Utah
Lang, J. B......Johnstone, Scotland
Lang, R. C.........New York, N. Y.
Lang, R. T...................
Heidenheim, Germany
Lang, W. H............Chicago, Ill.
Langdon, H. H.......Pullman, Wash.
Lange, F. F.........Worcester, Mass.
Lange, H. B.....Los Angeles, Calif.
Lange, M. E.........Cleveland, Ohio
Lange, O. C....S. Charleston, W. Va.
Lange, P. H......Bridgeport, Conn.
Langer, P.........Aachen, Germany
Langfitt, J. K.....Indianapolis, Ind.
Langhaar, L.........Allentown, Pa.
Langham, H. T...............
Kings Park, L. I., N. Y.
Langilie, H. B.......Berkeley, Calif.
Langlotz, R.....Staten Island, N. Y.
Langmuir, I.......Schenectady, N. Y.
Langner, F. W.........Olean, N. Y.
Langsdorf, A. S........St. Louis, Mo.
Langsner, A............Chicago, Ill.
Langstroth, C. B....Plainfield, N. J.
Langvand, I. L......Barberton, Ohio
Langworthy, R. A....New York, N. Y.
Langworthy, W. P..Brackenridge, Pa.
Lanier, H. D.................
Quemado de Guines, Cuba
Lanigan, T. M., Jr..Washington, D. C.
Lanning, J. E.......Clarkdale, Ariz.
Lannon, J. J...........Boston, Mass.
Lansing, C. B.......Cleveland, Ohio
Lansing, R. P.......E. Orange, N. J.
Lanus, P. J............Chicago, Ill.
Lanyon, L. H.......Melbourne, Aust.
Lanz, W. J..Long Beach, L. I., N. Y.
Lanzisera, J. C.....New York, N. Y.
Lapkin, J. D..........Kearny, N. J.
Lappin, J..........New York, N. Y.
Laquidara, A. K.....New York, N. Y.
La Raus, J.........New York, N. Y.
Lardner, H. A......New York, N. Y.
Larew, J. L........New York, N. Y.
Larkin, A. C....Montreal, Que., Can.
Larkin, D...........St. Louis, Mo.
Larkin, F. P...........Chicago, Ill.
Larkin, F. V.........Bethlehem, Pa.
Larkin, W. H., 3d............
Tompkinsville, S. I., N. Y.
Larkin, W. H., Jr...Arlington, Mass.
Larner, C. W.......Philadelphia, Pa.
Larocca, J. A.......New York, N. Y.
Laroche, J. J.........Cleveland, Ohio
Larrecq, A. J....Schenectady, N. Y.
Larsen, A. F......Terre Haute, Ind.
Larsen, A. M..........Solvay, N. Y.
Larsen, G. S.........Pittsburgh, Pa.
Larsen, H. E......Esbjerg, Denmark
Larson, C. B.......Maplewood, N. J.
Larson, C. M.......New York, N. Y.
Larson, C. W.......Worcester, Mass.
Larson, D. T...........Denver, Colo.
Larson, E. L...........Chicago, Ill.
Larson, G. L.........Madison, Wis.
Larson, G. W......Sugar Creek, Mo.
Larson, J. A.........Oakland, Calif.
Larson, J. E......Minneapolis, Minn.
Larson, N. F.........Hartford, Conn.
Larson, R. F...........Urbana, Ill.
Larsson, T. L. F....Worcester, Mass.
La Rue, A. B....Perth Amboy, N. J.
Lasciak, C..........Brooklyn, N. Y.
Laserna, A...................
Madrid, Colombia, S. A.
Lashbrook, T. S..........Moline, Ill.
Lask, F.............New York, N. Y.
Lasker, H. H. C.....New York, N. Y.
Lasko, C............New York, N. Y.
Laskowitz, I. B......Brooklyn, N. Y.
Lassalle, L. J......Baton Rouge, La.
Lassman, B.........Pittsburgh, Pa.
Lastner, C. A.........Baltimore, Md.
Latham, A., Jr........Boston, Mass.
Latham, B. W.....Mt. Vernon, N. Y.
Latham, H. M......Worcester, Mass.
Laton, T. J.........Durham, N. H.
Lattin, J.........Healdsburg, Calif.
Latzer, J. B........Coldwater, Ohio
Laubenstein, A. R......Ashland, Pa.
Lauck, A. W....Pompton Lakes, N. J.
Lauckner, C. G., 3d....E. Lynn, Mass.
Laudig, J. B..........Scranton, Pa.
Lauer, C. N........Philadelphia, Pa.
Lauer, R. J...........Detroit, Mich.
Lauffer, W. G......New York, N. Y.
Laughton, W. B.....Philadelphia, Pa.
Laukaitis, A., M.....Brooklyn, N. Y.
Lauman, H. E.....New York, N. Y.
Laurie, A......Montreal, Que., Can.
Lausche, L. F........Madison, Wis.
Laussucq, H. P. L....Birdsboro, Pa.
Lauterbach, G. E....New York, N. Y.
Lauterbach, H., Jr......Dallas, Tex.
Laux, J. P..........Bethlehem, Pa.
Law, C. J..............Lima, Ohio
Lawatsch, F. R......St. Paul, Minn.
Lawitz, L. L...........Chicago, Ill.
Lawrance, C. L........Linden, N. J.
Lawrence, A. D......Cleveland, Ohio
Lawrence, E. W........Decatur, Ga.
Lawrence, F. V......Elizabeth, N. J.
Lawrence, H. B....New York, N. Y.
Lawrence, H. F....Philadelphia, Pa.
Lawrence, J. H....New York, N. Y.
Lawrence, J. V.Long Island City, N. Y.
Lawrence, K. C........Camden, N. J.
Lawrence, K. W......Portland, Ore.
Lawrence, L. E....Indianapolis, Ind.
Lawrence, M. P......Glen Lyn, Va.
Lawrence, P...........Pitman, N. J.
Lawrence, S. F....New York, N. Y.
Lawrence, W. B..Washington, D. C.
Lawrence, W. H....New York, N. Y.
Lawrence, W. W....Brooklyn, N. Y.
Lawson, J. T........Newark, N. J.
Lawson, W. O......Arlington, N. J.
Lawton, H. H..........Rome, N. Y.
Lawton, M. A.........Boston, Mass.
Lay, L. C............Oil City, Pa.
Layat, F........Scotch Plains, N. J.
Lazarus, R. L.........Waltair, India
Lazear, W. B......E. Orange, N. J.
Leach, C. H........New York, N. Y.
Leach, H. E........Monterrey, Mex.
Leach, V. G...........Chicago, Ill.
Learmonth, A. C......El Paso, Tex.
Learnard, H. D......Lawrence, Mass.
Leary, G............New York, N. Y.
Leasenfeld, C...Jamaica, L. I., N. Y.
Leatherman, L. R.......Detroit, Mich.
Leavitt, E. E....Tufts College, Mass.
Leavitt, G. E., Jr....Cranford, N. J.
Le Baron, F. E....Binghamton, N. Y.
Lebbad, A. A.........Brooklyn, N. Y.
LeBlond, R. E.......Cincinnati, Ohio
LeBlond, R. K......Cincinnati, Ohio
Lebus, W. A...........Chicago, Ill.
Lechler, B. C......New York, N. Y.
Leclercq, L. E....Delawanna, N. J.
Le Conte, J. N......Berkeley, Calif.
Ledeen, H........Los Angeles, Calif.
Lederer, E. R.........Bradford, Pa.
Lederer, J.........New York, N. Y.
Ledgett, L. A........Berkeley, Calif.
Ledingham, W. E............
St. Laurent, Que., Can.
Lednum, J. M........Baltimore, Md.
Ledsham, W. H..Atlantic City, N. J.
LeDuc, R. J.........N. Quincy, Mass.
Lee, B. W..........Trenton, N. J.
Lee, C. C............Canton, China
Lee, E. R., Jr....Wood-Ridge, N. J.
Lee, F. B............Seattle, Wash.
Lee, F. H..........New York, N. Y.
Lee, G. F., III......Philadelphia, Pa.
Lee, G. M..........Springfield, Mass.
Lee, G. T...........Tangku, China
Lee, G. W.........New York, N. Y.
Lee, H. B.........New York, N. Y.
Lee, M. DeW........Rochester, N. Y.
Lee, R. J..........Philadelphia, Pa.
Lee, R. T..........Rochester, N. Y.
Lee, S............Los Angeles, Calif.
Lee, W. F............Richmond, Va.
Lee, W. R...................
Rio de Janeiro, Brazil, S. A.
Lee, W. S., Jr.......Charlotte, N. C.
Lee, Y..............Peiping, China
Leeds, B. L.........Hartford, Conn.
Leeds, C. C..........Pittsburgh, Pa.
Leeds, J. H......Los Angeles, Calif.
Leeper, R. W....Toronto, Ont., Can.
Leeson, M. G..........Lincoln, Neb.
Leet, L. N..........Cranford, N. J.
Leete, W. T......New Haven, Conn.
Leewitz, G. J..........Paris, France
Lefren, K. A..........Bogota, N. J.
Le Gette, M. A.....New York, N. Y.
Leggett, G. R......Waterbury, Conn.
Leggett, I. W..........Atlanta, Ga.
Leggett, W. D., Jr.Washington, D. C.
Leggo, W. F........New York, N. Y.
Legrand, C...........Douglas, Ariz.
Lehman, S.........Brooklyn, N. Y.
Lehman, W......S. Milwaukee, Wis.
Lehmann, M., Jr..Los Angeles, Calif.
Lehn, H. C...........Buffalo, N. Y.
Lehner, J. B........Brooklyn, N. Y.
Lehnerer, G..........Paducah, Ky.
Lehoczky, P. N......Columbus, Ohio
Lehr, C. E..........Bethlehem, Pa.
Lehr, P. E........Bakersfield, Calif.
Leigh, R. S..........Hoboken, N. J.
Leighton, A. J..........Chicago, Ill.
Leilich, F. T........Baltimore, Md.
Leininger, J. E....New Orleans, La.
Leipper, A. D......Philadelphia, Pa.
Leisen, T. A...........Omaha, Neb.
Leitch, H. W.......New York, N. Y.
Leitzell, F. O........Pittsburgh, Pa.
Lele, R. N.........Jamshedpur, India
Lelek, T. A........Bloomfield, N. J.
Lem, F. Y..........Shanghai, China
Lemaire, P............Lyons, France
Lemaistre, G., Jr.......Mexico, Mex.
Lembeck, O. A........Summit, N. J.
Lemery, J. W. R......Oakland, Calif.
Lemley, B. W..........Akron, Ohio
LeMont, F. H.........Wilmette, Ill.
Lenau, H. B........New York, N. Y.
Lenderoth, A. W....New York, N. Y.
Lenfest, B. A......Brooklyn, N. Y.
Leng, R. B...Prince Bay, S. I., N. Y.
Lenhard, R. E...Pleasantville, N. Y.
Lennig, F., Jr........Andalusia, Pa.
Lenno, E. J.......Watertown, N. Y.
Lenone, J. M...........Chicago, Ill.
Lentz, L. W..........Detroit, Mich.
Lenz, E............New York, N. Y.
Leonard, A. G...........Chicago, Ill.
Leonard, A. G., Jr..Wilmington, Ill.
Leonard, C. F......New York, N. Y.
Leonard, C. M......Stillwater, Okla.
Leonard, G. L........Pittsburgh, Pa.
Leonard, I.......London, Ont., Can.
Leonard, M. W......Irvington, N. J.
Leonard, N. N., Jr...........
Santa Monica, Calif.
Leonard, W. M.....New York, N. Y.
Leonhard, F. J.......Cleveland, Ohio
Leopoldoff, A......New York, N. Y.
LePage, C. B.......New York, N. Y.
Lerch, W. E..Long Island City, N. Y.
Leroy, W. W........Charlotte, N. C.
Leslie, B. S...........Miami, Fla.
Leslie, H.Rio de Janeiro, Brazil, S. A.
Leslie, J. S..........Wyckoff, N. J.
Leslie, R. B........Los Gatos, Calif.
Lesniak, F. G..........Laurel, Miss.
Lessells, J. M.......Cambridge, Mass.
Lesser, W. H..........Scranton, Pa.
Letchfield, F. T.San Francisco, Calif.
Lett, M. A....W. Falls Church, Va.
Leuang, W. A....E. Rutherford, N. J.
Leudemann, A. V....New York, N. Y.
Leunis, R..........Brooklyn, N. Y.
Leupold, H. W................
Tottenville, S. I., N. Y.
Leussler, A. J.........St. Louis, Mo.
Leutwiler, L. G.......N. Prairie, Wis.
Leutwiler, O. A..........Urbana, Ill.
Leverett, F. M....Port Arthur, Tex.
Leverett, W. H.......Houston, Tex.
Leverette, W. L....Kingsport, Tenn.
Leverich, J. W......Brooklyn, N. Y.
Levering, W. C.........Newark, N. J.
Levert, L. J........New York, N. Y.
Levine, B...........Brooklyn, N. Y.
Levine, D. B.......New York, N. Y.
Levine, H...........Harrison, N. J.
Levine, N. K.........Brooklyn, N. Y.
Levine, S...........Brooklyn, N. Y.
Levinger, D........New York, N. Y.
Levinson, H. J.......Philadelphia, Pa.
Levy, H..............Newark, N. J.
Levy, L. F.........Philadelphia, Pa.
Levy, M. W..........Houston, Tex.
Levy, S............New York, N. Y.
Lewis, A. H. G., Jr..Springfield, Mass.
Lewis, B. S.......New Britain, Conn.
Lewis, Chas. Finley....Houston, Tex.
Lewis, Chas. Fred'k..Knoxville, Tenn.
Lewis, D. E.........Rohrsburg, Pa.
Lewis, F. H.........Milwaukee, Wis.
Lewis, F. M.......Cambridge, Mass.
Lewis, F. S.........Stamford, Conn.
Lewis, G. Q.............Chicago, Ill.
Lewis, H. B.......Providence, R. I.
Lewis, H. H.........Pittsburgh, Pa.
Lewis, H. I..........Elizabeth, N. J.
Lewis, H. P........Wilmington, Del.
Lewis, I. R., Jr......Harrison, N. J.
Lewis, J. T..........Auburn, N. Y.
Lewis, N. E........New York, N. Y.
Lewis, P. J.......Framingham, Mass.
Lewis, Richard Campbell......
Mountain View, Calif.
Lewis, Richard Chas..Ansonia, Conn.
Lewis, R. E............Dallas, Tex.
Lewis, S. A.......New York, N. Y.
Lewis, W. D........New York, N. Y.
Lewthwaite, A. L....Pittsfield, Mass.
Libbey, R. H......New York, N. Y.
Libbey, W. S.........Lewiston, Me.
Libby, C. R........Norwalk, Conn.
Libby, J. M..................
Richmond Hill, L. I., N. Y.
Libby, M..........Somerville, Mass.
Libby, S. H........E. Orange, N. J.
Lichtenstein, J......New York, N. Y.
Lichty, L. C......New Haven, Conn.
Lidbury, F. A..Niagara Falls, N. Y.
Liddington, S. J..............
Hamilton, Ont., Can.
Liebowitz, B.......New York, N. Y.
Lienau, A. W......New York, N. Y.
Lienesch, C. F....Los Angeles, Calif.
Lifvergren, E. R....New York, N. Y.
Light, H. B..Long Island City, N. Y.
Lightowler, G. R..New York, N. Y.
Ligon, W. D.......New York, N. Y.
Lilla, H. L............Chicago, Ill.
Lillie, G. W....Salt Lake City, Utah
Lillieswan, S....Landskrona, Sweden
Limbacher, H. R....Columbus, Ohio
Limont, A. W., Jr..Wilmington, Del.
Linch, E. P........Philadelphia, Pa.
Lincoln, C. S.........W. Allis, Wis.
Lincoln, J. C.........Scottsdale, Ariz.
Lincoln, J. F.......Cleveland, Ohio
Lincoln, P. M........Ithaca, N. Y.
Lincoln, R. B.......Pittsburgh, Pa.
Lind, F. T...........Everett, Mass.
Lind, R. M.Southampton, L. I., N. Y.
Lindahl, F. M..W. Springfield, Mass.
Lindberg, A. E..........Moline, Ill.
Lindberg, F. A........Evanston, Ill.
Linde, G. F..........Madison, Wis.
Lindeke, H..........Martinez, Calif.
Lindell, W. F.........Newark, Del.
Lindemann, W. C....Milwaukee, Wis.
Lindemuth, F. L..Youngstown, Ohio
Lindenmeyer, C. E....Passaic, N. J.
Linder, T...........Memphis, Tenn.
Lindhagen, M. T..Stockholm, Sweden
Lindhard, S. N.....Brooklyn, N. Y.
Lindkvist, G. A...Stockholm, Sweden
Lindley, R. W....W. Lafayette, Ind.
Lindquist, D. L....New York, N. Y.
Lindquist, E. W..San Francisco, Calif.
Lindros, E. E.........Portland, Ore.
Lindsay, A..........Spokane, Wash.
Lindsay, G. L.........Franklin, Pa.
Lindseth, E. L.......Cleveland, Ohio
Lindsey, J. T.....E. Rochester, N. Y.
Lindsey, M. F...........Ames, Iowa
Lindsey, R., Jr....Los Angeles, Calif.
Lindsley, C. W........Detroit, Mich.
Lindstrom, A. W....Milwaukee, Wis.
Lindstrom, G. T.....Kenmore, N. Y.
Lindstrom, J. A.....Brooklyn, N. Y.
Lindstrom, N. O....Jersey City, N. J.
Lindstrom, O. W...Jersey City, N. J.
Lindstrom, W. J...Georgetown, Conn.
Lindford, J. W.......Auburn, N. Y.
Link, C. T.............Chicago, Ill.
Link, M. W...........Oak Park, Ill.
Link, R. L..........New York, N. Y.
Linke, F. J...........Elmira, N. Y.
Linker, J. I.....E. Rutherford, N. J.
Linnell, C. W..........Boston, Mass.
Linnenbruegge, H......Buffalo, N. Y.
Linsenmeyer, F. J....Detroit, Mich.
Linsley, L. N.........Newport, R. I.
Lintz, E. J..........Montclair, N. J.
Lipetz, A. I.......Schenectady, N. Y.
Liphshitz, I. N......New York, N. Y.
Lipke, L. H........New York, N. Y.
Lipp, E. L.......Los Angeles, Calif.
Lipp, J. E........Santa Monica, Calif.
Lippmann, A. W....Milwaukee, Wis.
Lippmann, E. E......Milwaukee, Wis.
Lipps, H., Jr...W. Palm Beach, Fla.
Liptay, J. M.......Crestwood, N. Y.

Lisciani, C......Chicago Heights, Ill.
Liskow, B. H........Saginaw, Mich.
Lister, A............Newark, N. J.
Lister, F. G........Springfield, Mo.
Lister, R. R..........Gatley, Eng.
Lister, S. M.........Portland, Ore.
Listo, W. H..................
Rockville Center, L. I., N. Y.
Litchfield, N......New York, N. Y.
Lithgow, J............Chicago, Ill.
Little, C. H.........Cleveland, Ohio
Little, E. R..........Detroit, Mich.
Little, H..........New York, N. Y.
Little, J. W.......Philadelphia, Pa.
Little, L. A............Dallas, Tex.
Littlefield, L. M.Chicopee Falls, Mass.
Littlefield, L. T.....Rochester, N. Y.
Littler, C. W.........Pittsburgh, Pa.
Littlewood, W..........Chicago, Ill.
Litty, F. E...........Detroit, Mich.
Liversidge, H. P....Philadelphia, Pa.
Livezey, W. B.....Newport News, Va.
Livingston, A. C..............
Kilmarnock, Scotland
Livingston, J. W......Swissvale, Pa.
Livingston, L. W.....Sayreville, N. J.
Livingston, R. T....New York, N. Y.
Livingstone, E. A....Beaver Falls, Pa.
Llauso, J......................
Buenos Aires, Argentina, S. A.
Lloyd, C. G..........Detroit, Mich.
Lloyd, J. A..........Harrison, N. J.
Lloyd, J. M........Knoxville, Tenn.
Lobben, P..........Skotbu, Norway
Loberg, H. J............Ithaca, N. Y.
Locke, E. D.......Los Angeles, Calif.
Locke, R. A.........Middletown, Pa.
Locke, W..........Wilmington, Del.
Lockeman, G. F.....Cincinnati, Ohio
Lockett, A. M......New Orleans, La.
Lockett, K.............Chicago, Ill.
Lockett, P. F.......Columbus, Ohio
Lockett, R. P......New Orleans, La.
Lockhart, E. R........El Paso, Tex.
Lockwenz, A. C.Elmhurst, L. I., N. Y.
Lockwood, F. A...Vevey, Switzerland
Lockwood, G. W...Bridgeport, Conn.
Lockwood, J. B. C.....Seattle, Wash.
Lockwood, M. H....New York, N. Y.
Lodge, H. M.......New York, N. Y.
Loeb, L...........New York, N. Y.
Loeffler, A..........New York, N. Y.
Loeffler, F.........New York, N. Y.
Loepsinger, A. J....Providence, R. I.
Loetscher, R. F.......Dubuque, Iowa
Loew, A. T.........Columbus, Ohio
Loewy, G. J.........New York, N. Y.
Lofft, W. A..........Camden, N. J.
Lofgren, G. E..Old Greenwich, Conn.
Lofgren, K. E......New York, N. Y.
Lofstedt, C. J.........Norfolk, Va.
Lofts, D............Cincinnati, Ohio
Loftus, J. J.........Worcester, Mass.
Logan, A........Staten Island, N. Y.
Logan, J. W......Conshohocken, Pa.
Logan, L............Baltimore, Md.
Logan, M. H......Jersey City, N. J.
Logan, O.......San Francisco, Calif.
Logue, C. H........Syracuse, N. Y.
Lohbiller, H. J........St. Louis, Mo.
Lohmann, C. G.......Holland, Mich.
Lohse, F. E.........Bloomfield, N. J.
Loidl, J. M..........Trenton, N. J.
Loizeaux, A. S.........Baltimore, Md.
Loman, J. K...........Kokomo, Ind.
Lombardi, A.........New York, N. Y.
Lombardi, W. A.........Derby, Conn.
Londahl, E. L.......Bordentown, N. J.
London, A. L..........Oakland, Calif.
Loney, N. McI........Detroit, Mich.
Long, D. R..........Lancaster, Pa.
Long, G. A..........Hartford, Conn.
Long, J. E...........Chicago, Ill.
Long, J. J..........Aberdeen, Wash.
Long, R. H..........Pensacola, Fla.
Long, R. C..........Syracuse, N. Y.
Long, S. W..........Torrance, Calif.
Longcoy, G. B........Cleveland, Ohio
Longenecker, C.....Philadelphia, Pa.
Longfellow, H. C...New York, N. Y.
Longfield, R..........Syracuse, N. Y
Longley, F. B........Oakland, Calif.
Longmaid, S. E........Villanova, Pa.
Longstreth, C.......Coronado, Calif.
Longwell, H. E......Syracuse, N. Y.
Loomis, A.............Elkhart, Ind.
Loomis, B., Jr..........Pierce, Fla.
Loomis, E. G.........Newark, N. J.
Loomis, F. K.........Hamilton, Ohio
Loomis, R. C.......Coronado, Calif.
Lootens, E. D..........Scranton, Pa.
Loppin, A. J.........New York, N. Y.
Lorange, J. O......Youngstown, Ohio
Lord, A. E..........Brooklyn, N. Y.
Lord, G. R.......Toronto, Ont., Can.
Lord, H. C............Lowell, Mass.
Lore, R. T., Jr......Philadelphia, Pa

Lormor, H. W.......Cleveland, Ohio
Losh, C. A......San Francisco, Calif.
Loss, H. v. Z......Philadelphia, Pa.
Loss, I. R..........New York, N. Y.
Losson, W. L.........Paterson, N. J.
Lott, H. P........Idaho Falls, Idaho
Lotz, C. W...........Pottsville, Pa.
Lotz, R. W...................
W. New Brighton, S. I., N. Y.
Loughery, W. E.....Philadelphia, Pa.
Loughran, J. J.......Pottstown, Pa.
Louppe, A.............Paris, France
Lourie, G. E..........Sheffield, Ala.
Loutrel, C. H.........Newark, N. J.
Louzecky, P. J.......Cleveland, Ohio
Love, C. P........Bellows Falls, Vt.
Lovejoy, E. P..........Detroit, Mich.
Lovejoy, F. P........Springfield, Vt.
Lovejoy, F. W......Rochester, N. Y.
Lovekin, R. E......Philadelphia, Pa.
Lovell, A..........Philadelphia, Pa.
Lovell, T. S..........Detroit, Mich.
Lovell, W. D.....Ipoh, Malay Penin.
Lovely, J. E..........Springfield, Vt.
Lovett, L. E........Cleveland, Ohio
Lovette, S. A..........Roanoke, Va.
Lowe, H. L.........New York, N. Y.
Lowe, S. S...........Johnstown, Pa.
Lowenstein, H. M...New York, N. Y.
Lower, N. M.......Hawthorne, N. J.
Lowman, A. H......New York, N. Y.
Lowrey, F. S.......Rochester, N. Y.
Lowry, C. M..........DeLand, Fla.
Lowry, E. G..........Seattle, Wash.
Lowry, G. A.........New York, N. Y.
Lowry, W. M........Kansas City, Mo.
Lowther, G. W.........Newgulf, Tex.
Lowther, W. G.....Port Arthur, Tex.
Loxterman, H. R......Evanston, Ill.
Loyd, A. E.........New York, N. Y.
Lozar, J. A.........Milwaukee, Wis.
Lubbe, W.....Vereeniging, S. Africa
Lubbert, G. L.........Baltimore, Md.
Lucarelle, J. M....Bridgeport, Conn.
Lucarelli, B. J.....Jersey City, N. J.
Lucas, C. W.........Bridgeton, N. J.
Lucas, H. M.........Cleveland, Ohio
Lucas, J. A.........New York, N. Y.
Luce, A. W..........Bethlehem, Pa.
Luce, R. S.........New York, N. Y.
Lucey, W. S.........Hoquiam, Wash.
Lucht, F. W., Jr......Meadville, Pa.
Lucke, C. E.........New York, N. Y.
Luckert, C. F., Jr.............
Corona, L. I., N. Y.
Luckie, G. O.......New York, N. Y.
Lucking, W. T......Englewood, Colo.
Luckner, L. B...Elmhurst, L. I., N. Y.
Lucy, S. G...Long Island City, N. Y.
Ludlow, G. R.......New York, N. Y.
Ludwickson, J. K......Lincoln, Neb.
Ludwig, A....Palisades Park, N. J.
Ludwig, W. W..Pickwick Dam, Tenn.
Ludy, L. V.......W. Lafayette, Ind.
Luebs, A. A..........Lincoln, Nebr.
Lueckel, W. J......New York, N. Y.
Luedicke, A. H......Milwaukee, Wis.
Luehrmann, H......New Orleans, La.
Luehrs, H...........Westerly, R. I.
Lufkin, G............Newark, Ohio
Lufkin, G. S.......New York, N. Y.
Lugrin, P............Logan, W. Va.
Luiggi, M. L.........Melbourne, Aust.
Lukens, A. N........New York, N. Y.
Lukens, W. L...........Dover, N. J.
Lukey, J. B..........Riverside, Ill.
Luks, K.............Princeton, N. J.
Luksch, A...........Iowa City, Iowa
Lull, E. E.........New York, N. Y.
Lund, N. B........New York, N. Y.
Lundberg, O. F.....New York, N. Y.
Lundbye, A. E.........Nunda, N. Y.
Lundgren, A. T..Santa Monica, Calif.
Lundgren, F. A......Brooklyn, N. Y.
Lundgren, I. H....Youngstown, Ohio
Lundh, S. H......Washington, D. C.
Lundquist, W. G......Paterson, N. J.
Lundqvist, A........New York, N. Y.
Lundstrom, C. B...Little Falls, N. Y.
Lundt, E. C.......New York, N. Y.
Lundy, W. L.....Michigan City, Ind.
Luney, F. S.........E. Chicago, Ind.
Lunghard, C. F....New York, N. Y.
Lunn, J. A........Cambridge, Mass.
Lupke, P., Jr.........Trenton, N. J.
Lupton, W. W....Los Angeles, Calif.
Lusk, J. B............Bethlehem, Pa.
Lusk, S. W...........Newark, N. J.
Lustig, J. D...........Chicago, Ill.
Luther, W. L., Jr.White Plains, N. Y.
Lutz, G...........New York, N. Y.
Lux, A. E.............Peoria, Ill.
Lyall, J. D.......Glens Falls, N. Y.
Lyall, W. L........Ridgewood, N. J.
Lydall, C. H.......New York, N. Y.
Lyerly, R. F...Granite Quarry, N. C.
Lyford, F. E.....Philadelphia, Pa

Lyke, H. W...........Detroit, Mich.
Lyle, E. L.............Alcoa, Tenn.
Lyle, E. T........New York, N. Y.
Lyman, O. B....San Francisco, Calif.
Lyman, W. R........Westfield, Mass.
Lynah, J..............Ithaca, N. Y.
Lynam, W. A...........Chicago, Ill.
Lynch, E. A........Philadelphia, Pa.
Lynch, J. E., Jr.....Winthrop, Mass.
Lynch, T. J...........Boston, Mass.
Lyon, A. H...........Rockford, Ill.
Lyon, J. F.........Providence, R. I.
Lyon, P. S.........New York, N. Y.
Lyon, W. H.........Shreveport, La.
Lyons, B. J........Cumberland, Md.
Lyons, D. A......Los Angeles, Calif.
Lyons, H. R..........Oswego, N. Y.
Lyons, W. T........New York, N. Y.
Lyster, T. L. B...Niagara Falls, N. Y.
Lytle, C. W........New York, N. Y.
Lytle, J. E.........New York, N. Y.
Lytle, W. O.........Pittsburgh, Pa.

M

Maage, A. E., Jr....Milwaukee, Wis.
Maak, C...........New York, N. Y.
Maas, E. F.............Akron, Ohio
Mabb, W. S...........Bristol, Conn.
Mabee, E. W...........Detroit, Mich.
Mabey, A. R.......Waterbury, Conn.
Mabley, C. R., Jr.....Boston, Mass.
Mabley, T. H..........Detroit, Mich.
MacAfee, R. E...Montreal, Que., Can.
MacAllister, J. W..Prospect Park, Pa.
MacArthur, C. J....Glen Ridge, N. J.
MacArthur, R......New Haven, Conn.
Macaulay, D. S..San Francisco, Calif.
MacBriar, W. N.....Milwaukee, Wis.
MacCamy, H. J......Spokane, Wash.
MacCarthy, P. W...Springfield, Mass.
MacClarence, J.......Baltimore, Md.
Macconochie, A. F....University, Va.
MacCubbin, A. A....Montclair, N. J.
MacCullough, G. H..Worcester, Mass.
MacDonald, E. D.....Brooklyn, N. Y.
MacDonald, E. T..............
Forest Hills, L. I., N. Y.
MacDonald, J., Jr...Philadelphia, Pa.
MacDonald, J. W. F...Boston, Mass.
MacDonald, K......Wellsville, N. Y.
MacDonald, M. J..............
Long Island City, N. Y.
MacDonald, R. G....New York, N. Y.
MacDowell, M. H........Easton, Pa.
Macek, F. J.......Manchester, N. H.
MacElwee, R. S....New York, N. Y.
MacFadyen, F. R., Jr...Canton, Ohio
MacFarlane, J.Sagua La Grande, Cuba
MacFarlane, W. C.Minneapolis, Minn.
MacGillis, D. J........Detroit, Mich.
MacGowan, J. F.....New York, N. Y.
MacGrath, K.......E. Orange, N. J.
MacGregor, C. W...Cambridge, Mass.
MacGregor, D. D.......Tokyo, Japan
MacGregor, W. F.......Racine, Wis.
Machold, C. E......Philadelphia, Pa.
Maci, R. J.............Chicago, Ill.
Macias, C.............Mexico, Mex.
MacIntyre, H. D....New York, N. Y.
Mack, A. J.........Manhattan, Kan.
Mack, F. F.........Norwalk, Conn.
Mack, J. J., Jr........Bayonne, N. J.
Mackal, H. H.......New York, N. Y.
MacKamey, R.....Long Beach, Calif.
Mackay, G. W.........Paterson, N. J.
MacKay, S.............Athol, Mass.
Mackay, T. R.........Cypress, Calif.
MacKenzie, F. C..Lachine, Que., Can.
Mackenzie, H. A......Cleveland, Ohio
MacKenzie, J. A.....Pittsburg, Calif.
Mackenzie, J. W......Jackson, Mich.
Mackenzie, K. D...State College, Pa.
Mackenzie, K. G.....New York, N. Y.
Mackenzie, M......Phillipsdale, R. I.
MacKenzie, N. W....Brooklyn, N. Y.
Mackenzie, W. P....Philadelphia, Pa.
Mackey, G.........Kings Mills, Ohio
MacKinnon, C........Plymouth, Mass.
Mackie, D. M.......Milwaukee, Wis.
Mackintosh, D.........Neenah, Wis.
Mackintosh, W. D.......Tulsa, Okla.
Macklem, G. A..........Beloit, Wis.
Macklin, R. W......Worcester, Mass.
Macklind, W. R.........Chicago, Ill.
Maclachlan, A. D........Akron, Ohio
Maclaren, J. E.....Birmingham, Eng.
Maclaren, J. G...San Francisco, Calif.
MacLaren, M. N.....Van Nuys, Calif.
MacLaren, T. F.....Philadelphia, Pa.
Maclean, D........Waterbury, Conn.
MacLean, J. A......Notre Dame, Ind.
MacLean, W. W......Oakland, Calif.
MacLehose, M........Caldwell, N. J.
MacLeod, A. S....Amsterdam, N. Y.
MacLeod, D. T......Milwaukee, Wis.

MacLeod, L. R.................
Hastings-on-Hudson, N. Y.
MacLeod, N. D....Providence, R. I.
MacMeeken, J. W....Berkeley, Calif.
MacMillan, D. C....San Pedro, Calif.
MacMillan, D. S......Dedham, Mass.
MacNabb, C..........Newark, N. J.
MacNamara, M. J........Rye, N. Y.
MacNaughton, E..W. Somerville, Mass.
Macneale, N., Jr.......St. Louis, Mo.
Macnee, C. M.........Alloa, Scotland
MacNeille, M. B.........Beloit, Wis.
MacNeish, A. S........Boston, Mass.
Macomber, J. K.....Brooklyn, N. Y.
Macorra, J. de la......Mexico, Mex.
MacPherson, D. A...Milwaukee, Wis.
MacPherson, G. R...Richmond, Calif.
MacSweeney, H. M.............
San Francisco, Calif.
MacVenn, M. J....New York, N. Y.
Macwatty, F. L....New York, N. Y.
Macy, R. G.........New York, N. Y.
Madden, J. A.........Oakland, Calif.
Maddison, R. J......New Castle, Pa.
Madeheim, H.......New York, N. Y.
Mader, C. K.................
Jackson Heights, L. I., N. Y.
Madison, R. D..........Buffalo, N. Y.
Madlem, D. W........El Paso, Tex.
Madsen, S.............Clinton, Iowa
Maffey, W. L........Berkeley, Calif.
Magalhaes, W. S....New York, N. Y.
Magdeburger, E. C.Washington, D. C.
Magee, G. H........New York, N. Y.
Maggio, P. P.........Brooklyn, N. Y.
Maggioli, G. J.........Benicia, Calif.
Maggs, A...........New York, N. Y.
Magill, F. R..........Pittsburgh, Pa.
Maginnis, W. S......New York, N. Y.
Magis, A. A. G........Paris, France
Maglathlin, S. A.....Needham, Mass.
Magrath, H. A.....Cambridge, Mass.
Magraw, L. A.........Springfield, Ill.
Maguire, J. D.......New York, N. Y.
Maguire, J. H..........Kokomo, Ind.
Mahan, O. E.........Rochester, N. Y.
Mahar, J. J...........Boston, Mass.
Maher, E. E............Chicago, Ill.
Maher, N. W........Cleveland, Ohio
Mahl, F. W..........Berkeley, Calif.
Mahon, W. J...........Mexico, Mex.
Mahone, F. D.....Long Beach, Calif.
Mahoney, H. J......New York, N. Y.
Maier, A. R............Dallas, Tex.
Maier, D. C..........Detroit, Mich.
Maier, H...........Cincinnati, Ohio
Maier, H. L., Jr....Wilmington, Del.
Maier, W. H..........Newark, N. J.
Maillard, A. L.....Kansas City, Mo.
Mailler, J. P.......New York, N. Y.
Main, C. R............Boston, Mass.
Main, C. T............Boston, Mass.
Main, J. M...........Cleveland, Ohio
Maine, W. C.........New York, N. Y.
Mair, K. T...........Plainfield, N. J.
Majercik, A. S..........Chicago, Ill.
Maker, F. L.....San Francisco, Calif.
Malby, S. G........Edgewater, N. J.
Malcolm, G. H.........Chicago, Ill.
Maleev, V. L.........Stillwater, Okla.
Maley, F. M.......Ridley Park, Pa.
Malischke, C........Milwaukee, Wis.
Mallina, R. F.......New York, N. Y.
Mallinckrodt, E., Jr....St. Louis, Mo.
Mallon, F. J.........Columbus, Ohio
Mallory, B. C.........Boston, Mass.
Mallory, H. R...S. Manchester, Conn.
Mallory, W. F.........Boulder, Colo.
Malloy, J. F.....Glen Ferris, W. Va.
Mally, G. G..........Detroit, Mich.
Malone, J. F.........Baltimore, Md.
Maloney, M. J...........Troy, N. Y.
Maloney, S. C.........Detroit, Mich.
Malvern, L. K...........Elgin, Ill.
Mange, L. B......Los Angeles, Calif.
Mangels, H. E................
St. Albans, L. I., N. Y.
Mangelsdorf, T. A..Port Arthur, Tex.
Manger, P. A.........Buffalo, N. Y.
Mangini, F. A., Jr...New York, N. Y.
Mangold, C. P.......Audubon, N. J.
Mangold, R.........Springfield, Mass.
Manierre, G..........Milwaukee, Wis.
Mankin, G. M...........Atlanta, Ga.
Manley, H. W...........Tulsa, Okla.
Manley, S. M.......Cincinnati, Ohio
Mann, C. P............Seattle, Wash.
Mann, H. B..........Pittsburgh, Pa.
Mann, J.........Seneca Falls, N. Y.
Mann, R. M.........Plattsmouth, Neb.
Mann, T. E.......Coulee Dam, Wash.
Manney, C. J.......New Orleans, La.
Manning, C. H..........Richmond, Va.
Manning, W. T.....Philadelphia, Pa.
Mansfield, J. H.........Rockford, Ill.
Mansfield, R. C........Portland, Me.
Mantius, O.........New York, N. Y.

Manville, W. W........Troy, N. Y.
Manz, J. W..........Chicago, Ill.
Manz, L. C.......Philadelphia, Pa.
Marble, G. C.......Skowhegan, Me.
Marburg, L. C......New York, N. Y.
Marcero, A..........Detroit, Mich.
Marchant, J. H......New York, N. Y.
Marchant, R. D...Schenectady, N. Y.
Marcy, L. B..........Oneida, N. Y.
Marden, J. S.........Seattle, Wash.
Marice, P. J.......New Orleans, La.
Marin, J.......New Brunswick, N. J.
Marino, D. A......New York, N. Y.
Marino, S. F.........Bristol, Conn.
Marion, F. I.........St. Louis, Mo.
Mark, W. J...........Chicago, Ill.
Marker, R. H..........Toledo, Ohio
Markert, E. R.......Hartford, Conn.
Markey, H. I......Philadelphia, Pa.
Markfelder, C. F....New York, N. Y.
Markland, G. L., Jr..........
Philadelphia, Pa.
Markle, F. S.........Houston, Tex.
Markovits, T..........Newark, N. J.
Marks, H. J......Mamaroneck, N. Y.
Marks, H. M........New York, N. Y.
Marks, L. S........Cambridge, Mass.
Markson, A. A...............
Kew Gardens, L. I., N. Y.
Mark-Wardlaw, A. L. P........
Washington, D. C.
Marlow, H. L........Charlotte, N. C.
Marmont, E. L..........Gary, Ind.
Marple, P. G.....Youngstown, Ohio
Marquis, F. P......Rochester, N. Y.
Marquis, F. W......Columbus, Ohio
Marran, V. P........Holyoke, Mass.
Marroquin, C. F........Mexico, Mex.
Marsh, A. B..........Boston, Mass.
Marsh, G. E........St. Paul, Minn.
Marsh, H. B........Hagerstown, Ind.
Marsh, H. S..Long Island City, N. Y.
Marsh, J. D......New Haven, Conn.
Marsh, T. A..........Chicago, Ill.
Marshall, A. G..San Francisco, Calif.
Marshall, A. R..Hudson Falls, N. Y.
Marshall, C. C., Jr...........
Natural Bridge, Ky.
Marshall, E. S.....Birmingham, Ala.
Marshall, E. W....New York, N. Y.
Marshall, H. F........Camden, N. J.
Marshall, J. C........St. Louis, Mo.
Marshall, J. T......E. Orange, N. J.
Marshall, J. W......Arlington, N. J.
Marshall, R. C., Jr.Washington, D. C.
Marshall, S. M..San Francisco, Calif.
Marshall, S. W., Jr......Dallas, Tex.
Marshall, T. H., Jr..........
Schenectady, N. Y.
Marshall, W........Stamford, Conn.
Marsilio, B..........Paterson, N. J.
Marston, C. D...........York, Pa.
Martel, F. A..........Havana, Cuba
Martel, J. P...........Chicago, Ill.
Martellotti, E. M....Cincinnati, Ohio
Martenis, J. V....Minneapolis, Minn.
Martensson, M......New York, N. Y.
Marth, H...........Rochester, N. Y.
Marti, C............Detroit, Mich.
Martin, C. H........E. Orange, N. J.
Martin, C. R........Milwaukee, Wis.
Martin, D. W.......Worcester, Mass.
Martin, E. C.......Kansas City, Mo.
Martin, E. J........Cincinnati, Ohio
Martin, E. S.....Toronto, Ont., Can.
Martin, G. F..Northport, L. I., N. Y.
Martin, G. W......New York, N. Y.
Martin, H. B...........York, Pa.
Martin, H. C..................
S. Ozone Park, L. I., N. Y.
Martin, H. E......New York, N. Y.
Martin, H. H., Jr..New York, N. Y.
Martin, J..........New York, N. Y.
Martin, J. A..........Norfolk, Va.
Martin, J. C., Jr..Los Angeles, Calif.
Martin, K. L.......New York, N. Y.
Martin, L. H.......Waynesboro, Pa.
Martin, R...........Palmerton, Pa.
Martin, R. E........Springdale, Pa.
Martin, R. J., Jr........Atlanta, Ga.
Martin, R. W......Middletown, Ohio
Martin, V. J..........Venice, Calif.
Martin, W. H........Corvallis, Ore.
Martinez, C. J........Mexico, Mex.
Martinez, J. J.........Mexico, Mex.
Martinto, P.......New York, N. Y.
Martorano, P....Corona, L. I., N. Y.
Martus, M. L......Waterbury, Conn.
Maruffi, J. P.........Vineland, N. J.
Marum, H...........Brooklyn, N. Y.
Marum, O........Binghamton, N. Y.
Marx, E...........New York, N. Y.
Marx, H..........Cincinnati, Ohio
Marzolf, J. M....Washington, D. C.
Marzoli, L...........Brescia, Italy
Masek, C. A. M....New York, N. Y.
Masino, F. D........Brooklyn, N. Y.

Masland, C. H., 2d......Carlisle, Pa.
Mason, C...........Rockford, Ill.
Mason, H. A.........Webster, N. Y.
Mason, H. L........Rochester, N. Y.
Mason, H. W.........Atlanta, Ga.
Mason, J. E..........Denver, Colo.
Mason, J. W., Jr......Houston, Tex.
Mason, M. A......Washington, D. C.
Mason, O. F...........Toledo, Ohio
Mason, S. C.........Melrose, Mass.
Mason, S. P.........Trenton, N. J.
Mason, W. A....Palm Springs, Calif.
Mason, W. E......Los Angeles, Calif.
Mason, W. H.........Laurel, Miss.
Massa, R. F.......New York, N. Y.
Massey, A. G..........Chicago, Ill.
Masson, H. J.......New York, N. Y.
Master, J. N........Bombay, India
Masters, J.Richmond Hill, L. I., N. Y.
Matchett, J. C..........Chicago, Ill.
Mather, A. J..........Kewanee, Ill.
Mather, R. H..Windsor Locks, Conn.
Mather, T. H........Cleveland, Ohio
Mathews, H. H....Washington, D. C.
Mathews, H. M.......Thomasville, Ga.
Mathews, N. P......Charlotte, N. C.
Mathews, R. T.......Durham, N. C.
Mathews, W. B........Whiting, Ind.
Mathews, W. E....S. Norwalk, Conn.
Mathews, W. L....Sugar Creek, Mo.
Mathewson, J. S......Madison, Wis.
Mathewson, A. I....Providence, R. I.
Mathieu, J...........Houston, Tex.
Matlack, E. V......River Forest, Ill.
Matlock, C........New York, N. Y.
Matschoss, C.......Berlin, Germany
Matsen, M. M........Bonner, Mont.
Matson, C. H......Fort Wayne, Ind.
Matson, R. M.........Atlanta, Ga.
Matter, G. O.........Portland, Ore.
Mattern, J. F......Wilkinsburg, Pa.
Matteson, R........Richmond, Calif.
Matteson, R. J..........Chicago, Ill.
Matthes, M. H......Cleveland, Ohio
Matthews, B. H.........Denver, Colo.
Matthews, H. E......Charlotte, N. C.
Matthews, R. G.......Orange, N. J.
Matthews, W. E..Phillipsburg, N. J.
Matthieson, H..........Oil City, Pa.
Mattison, A. C........Rockford, Ill.
Mattison, E. F......Springfield, Ohio
Mattke, C. F.......New York, N. Y.
Mattlage, R. F. L...New York, N. Y.
Mattson, I. F..........Banes, Cuba
Mattsson, A. L......Pittsburgh, Pa.
Matukas, J. J.........Allston, Mass.
Matz, C. L...........Reading, Pa.
Mauger, D. N.......New York, N. Y.
Maulbetsch, J. L....Ann Arbor, Mich.
Maule, A. C.......Philadelphia, Pa.
Maull, W. R.........St. Davids, Pa.
Maurer, E. R.........Madison, Wis.
Maurer, H. L...........Gary, Ind.
Maurer, W. R.........Teaneck, N. J.
Mauricette, R. E.......Durham, N. H.
Mavis, F. T........Iowa City, Iowa
Maw, A. E...........London, Eng.
Mawhinney, M. H........Salem, Ohio
Mawson, R...........Chicago, Ill.
Maxfield, D. E.......Philadelphia, Pa.
Maxfield, H. H.....Wilmington, Del.
Maxon, B. E........Cincinnati, Ohio
Maxwell, G. L.......Philadelphia, Pa.
Maxwell, M. C......Stamford, Conn.
May, D. H.......Cabin Creek, W. Va.
May, E. A............Chicago, Ill.
May, E. D........Winchendon, Mass.
May, Edward M......Oak Park, Ill.
May, Edwin M......New York, N. Y.
May, S. C........New York, N. Y.
Mayer, F..........New York, N. Y.
Mayer, J. K.......New Orleans, La.
Mayer, L.............Boston, Mass.
Mayer, R. L......Los Angeles, Calif.
Mayers, M. A........Pittsburgh, Pa.
Mayes, C......Oklahoma City, Okla.
Mayfield, W. W..Clarksburg, W. Va.
Mayhew, B. A.Long Island City, N. Y.
Mayhew, R. D.........Lancaster, Pa.
Maynard, C. E..Chicopee Falls, Mass.
Mayo, A. R..........Kearny, N. J.
Mayo, E. C........Providence, R. I.
Mayo, J. B........Greenville, S. C.
Mayo, W. B...........Detroit, Mich.
Mayr, K. A.........Munich, Germany
Mayrose, H. E........Detroit, Mich.
Mays, J. S........Washington, D. C.
Mayse, G. F......Wilmington, Calif.
Maytham, W. J....Mason City, Iowa
Mazaika, J.........Brooklyn, N. Y.
Mazurie, J. V...........Gary, Ind.
McAdam, H. B....Thorold, Ont., Can.
McAdams, J. E.....Springfield, Ohio
McAfee, W. K.......New Castle, Pa.
McAllister, Alex. Jos....Chicago, Ill.
McAllister, Alfred J..Lafayette, Ind.
McAninch, H. A....Indianapolis, Ind.

McArdell, W. E......Brooklyn, N. Y.
McAuley, B. F..........Chicago, Ill.
McAuley, McG. M.....Jackson, Miss.
McAuliffe, P. J..Baldwinsville, N. Y.
McBean, D. M....Canajoharie, N. Y.
McBee, E. L..........Toledo, Ohio
McBerty, D. R........Warren, Ohio
McBride, J. J.......New York, N. Y.
McBride, T. C......Philadelphia, Pa.
McBride, W. J....Phillipsburg, N. J.
McBrien, R. E..Peterboro, Ont., Can.
McBryde, W. H..San Francisco, Calif.
McBurney, J. W..Washington, D. C.
McCabe, F. E........Cleveland, Ohio
McCabe, J. C........Detroit, Mich.
McCall, D..........Berkeley, Calif.
McCallister, E. W....Pittsburgh, Pa.
McCammond, W. W..Brooklyn, N. Y.
McCanna, F. J.........Buffalo, N. Y.
McCanna, L. A........Buffalo, N. Y.
McCarthy, E.......New York, N. Y.
McCarthy, E. R.....Cleveland, Ohio
McCarthy, E. W......Galveston, Tex.
McCarthy, H..........Kewanee, Ill.
McCarthy, J. H.......Everett, Wash.
McCarthy, J. J.....Philadelphia, Pa.
McCarthy, R. H....New York, N. Y.
McCarty, R. A......Wilkinsburg, Pa.
McCarty, R. J., Jr....Bethlehem, Pa.
McCaslin, S. N......Worcester, Mass.
McCaughan, G. J....Brooklyn, N. Y.
McCausland, J. R..Philadelphia, Pa.
McCausland, J. W......Chicago, Ill.
McCaw, W. W..........Omaha, Neb.
McChesney, I. G....Rochester, N. Y.
McClain, R. G........Columbia, Mo.
McClain, R. E..........Peoria, Ill.
McClaren, W. L........Oil City, Pa.
McClarity, J. T....New York, N. Y.
McClellan, W......Washington, D. C.
McClelland, C. C....Cleveland, Ohio
McClelland, E. S..E. Pittsburgh, Pa.
McClennan, W. J....Cleveland, Ohio
McClintock, A. P....Pittsburgh, Pa.
McClintock, F. S....Pittsburgh, Pa.
McClintock, J. P........Chicago, Ill.
McCloughan, C....E. Norwalk, Conn.
McClung, J. M....N. Andover, Mass.
McClure, C. R......Cleveland, Ohio
McClure, D. D....Ishpeming, Mich.
McClure, O. D......Ishpeming, Mich.
McConaghy, J. W..Phillipsburg, N. J.
McConahey, H. M..Waterbury, Conn.
McConnell, C. W........Warren, Pa.
McConnell, G...........Tulsa, Okla.
McConnell, J. W......Newport, R. I.
McConnell, M. F.......Munhall, Pa.
McConnell, M. R....Pittsburgh, Pa.
McConnell, R. S....Philadelphia, Pa.
McCord, C. M......Memphis, Tenn.
McCormack, D. J.........York, Pa.
McCormack, R. F., Jr.........
Brooklyn, N. Y.
McCormick, F. H......Dayton, Ohio
McCormick, M. H......Chicago, Ill.
McCoy, T. A......Emeryville, Calif.
McCoy, V. E..........Chicago, Ill.
McCoy, W..........Zanesville, Ohio
McCracken, S. P....Kansas City, Mo.
McCracken, W. C....Columbus, Ohio
McCrady, L. deB.Montreal, Que., Can.
McCrary, J. A....Washington, D. C.
McCreery, J. H....New York, N. Y.
McCrohan, E. B., Jr..........
Rockville Center, L. I., N. Y.
McCue, J. O.......Springdale, Conn.
McCulloch, J. A........Denver, Colo.
McCullough, J., Jr....Seattle, Wash.
McCullough, W. T., Jr.Pittsburgh, Pa.
McCune, C. A......New York, N. Y.
McCune, J. C.......Wilmerding, Pa.
McCutchan, A........Detroit, Mich.
McCutcheon, A..St. Johns, Que., Can.
McCutcheon, A. C....Hopewell, Va.
McDermott, C. C....New York, N. Y.
McDevitt, J. N.....Pawtucket, R. I.
McDonald, D.......New York, N. Y.
McDonald, E. L....Kansas City, Mo.
McDonald, J. J........Detroit, Mich.
McDonald, J. N......Paterson, N. J.
McDonald, R. D....Philadelphia, Pa.
McDonald, W. A......Houston, Tex.
McDonough, P. W....Oakland, Calif.
McDougall, G. F......Portland, Ore.
McDowell, D. W....Philadelphia, Pa.
McDowell, R. W..............
Long Island City, N. Y.
McDowell, W. E......Spencer, N. C.
McElhose, L. G.........Flint, Mich.
McElroy, J. H....Pearl River, N. Y.
McElroy, J. J.........Boston, Mass.
McElroy, P. S......Providence, R. I.
McEntee, J. R....Long Beach, Calif.
McEver, W. L.........Decatur, Ga.
McEwan, T. S.........Chicago, Ill.
McFadden, B. C......Pittsburgh, Pa.
McFarland, E. H.......Philo, Ohio

McGahey, R. E........Potomac, Va.
McGann, R. G.........Chicago, Ill.
McGarr, A. F..San Francisco, Calif.
McGee, F. R......Steubenville, Ohio
McGee, J. J....Montreal, Que., Can.
McGee, W. A........Cleveland, Ohio
McGeorge, G. G....Cincinnati, Ohio
McGibbon, D. G....Rutherford, N. J.
McGill, W. A....San Francisco, Calif.
McGinn, L. F......Providence, R. I.
McGladrey, L. L.......Chicago, Ill.
McGoldrick, J. K......Tulsa, Okla.
McGonigle, C........Portland, Ore.
McGown, J. A...........Moline, Ill.
McGrath, H. D....Hackensack, N. J.
McGrath, J. F.......Yonkers, N. Y.
McGrath, P. C.......Alhambra, Calif.
McGraw, J. H......New York, N. Y.
McGregor, A. G........London, Eng.
McGregor, H. L......Detroit, Mich.
McGregor, J. McK.......Tulsa, Okla.
McGrew, F. R.......Shreveport, La.
McGrew, J. A.........Albany, N. Y.
McGuckian, J.........Lewiston, Me.
McGuire, D. E........Detroit, Mich.
McGuire, E. J......Rochester, N. Y.
McGuire, F., Jr........Bogota, N. J.
McGuire, T. G.......Stonington, Me.
McHale, W. L.....New York, N. Y.
McHugh, A. G....Youngstown, Ohio
McHugh, A. L....Phillipsburg, N. J.
McIlhenney, W.......Arlington, N. J.
McIlhiney, J. G.......Summit, N. J.
McIlvaine, C. L., Jr..Eddystone, Pa.
McIlvaine, J. H........Chicago, Ill.
McIntire, C. V......New York, N. Y.
McIntire, J. F........Detroit, Mich.
McIntosh, D. C......Cleveland, Ohio
McIntosh, R.....Lake Linden, Mich.
McIntosh, S. A......Shreveport, La.
McIntosh, W. G..Toronto, Ont., Can.
McIntosh, W. J.......Seattle, Wash.
McIntyre, H. J.......Seattle, Wash.
McIntyre, M.........Bayonne, N. J.
McIntyre, O. L....San Carlos, Calif.
McIntyre, W. S........Milton, Mass.
McIver, A.........New York, N. Y.
McKaig, W. W.....Cumberland, Md.
McKay, J. B..........Panama, C. A.
McKay, W. M......Honolulu, T. H.
McKean, C. V.........Houston, Tex.
McKee, A. G........Cleveland, Ohio
McKee, H., Jr.......Cohoes, N. Y.
McKee, N. C........Alhambra, Calif.
McKee, N. T......New York, N. Y.
McKee, T. C..........Chicago, Ill.
McKee, W..........Cleveland, Ohio
McKee, W. McC.....New York, N. Y.
McKelvie H. M....Gastonia, N. C.
McKelvy, F. G..........Easton, Pa.
McKenna, J. F.......Saginaw, Mich.
McKenna, R. C.........Latrobe, Pa.
McKenney, J. F..Schenectady, N. Y.
McKenzie, J. C. S.New Rochelle, N. Y.
McKeown, G. M.........Detroit, Mich.
McKeown, J. A....New York, N. Y.
McKernan, H. J......Saginaw, Mich.
McKiever, W. H....New York, N. Y.
McKinlay, J.........Oakland, Calif.
McKinley, G. W..Clarksburg, W. Va.
McKinney, A. G.........Miami, Fla.
McKinney, G. C......Ft. Worth, Tex.
McKnight, C. H.......Scranton, Pa.
McKnight, E. W......Live Oak, Fla.
McKnight, W. H., Jr..Detroit, Mich.
McLain, B..........Pittsburgh, Pa.
McLain, R. H......New York, N. Y.
McLane, R. M........Columbia, Pa.
McLaren, L. L.........Chicago, Ill.
McLarney, W. J........Chicago, Ill.
McLaughlin, G. E....Peabody, Mass.
McLauthlin, M. B......Boston, Mass.
McLean, H. D........Shreveport, La.
McLean, J. S......New York, N. Y.
McLean, R. W....Bridgewater, Mass.
McLean, W. H........Boston, Mass.
McLellan, E. A....New Orleans, La.
McLelland, A.........Newark, N. J.
McLennan, J. A.......Denver, Colo.
McMacken, D. C.........Flint, Mich.
McMahan, R. G........Chicago, Ill.
McMahon, C. M......Westboro, Mass.
McMahon, J., Jr..Sag Harbor, N. Y.
McMahon, Jerome B....Sharon, Mass.
McMahon, John B......Donora, Pa.
McManmon, J. C....Bay City, Mich.
McManus, J. D....Greensburg, Pa.
McMeekin, B. M....Philadelphia, Pa.
McMein, E. C......New York, N. Y.
McMenamin, C. G..Philadelphia, Pa.
McMillan, A........Brooklyn, N. Y.
McMillan, C. E........Havana, Cuba
McMillen, A. K......Pittsburgh, Pa.
McMillin, F. B......Mt. Gilead, Ohio
McMinn, B. T........Seattle, Wash.
McMullen, G. C......Massillon, Ohio
McMullen, V. E......Columbus, Ind.

McMurray, J. D., Jr....Dallas, Tex.
McMurray, J. H..Bound Brook, N. J.
McNair, A. M....Calgary, Alta., Can.
McNairy, A. B......Cleveland, Ohio
McNally, K. J......New York, N. Y.
McNamara, R. A......Easton, Mass.
McNeal, D. R......Philadelphia, Pa.
McNear, W. F......W. Orange, N. J.
McNeill, K. S.........Mexico, Mex.
McNeil, M. C.........Marion, Ohio
McNeill, N. S....Los Angeles, Calif.
McNeill, T. W..........Chicago, Ill.
McNellis, J. S........Boston, Mass.
McNulty, D. L......Pittsburgh, Pa.
McPartland, M. B......Chicago, Ill.
McPeak, B. D........Midland, Mich.
McPhee, A. H......Brooklyn, N. Y.
McPherson, J. A....Greenville, S. C.
McPherson, W. J......Seattle, Wash.
McQuaid, D. J.......Denver, Colo.
McQueeney, J. T....Brooklyn, N. Y.
McQuesten, F. W........Barre, Mass.
McQuilkin, G., Jr..Philadelphia, Pa.
McQuillan, J......New York, N. Y.
McQuiston, W. B....Pittsburgh, Pa.
McReynolds, G. S..Chattanooga, Tenn.
McSwain, W. D....E. Walpole, Mass.
McSweeney, J..San Francisco, Calif.
McSweeney, W. T..............
Barranca-Bermeja, Colombia, S. A.
McVetty, P. G....E. Pittsburgh, Pa.
McVey, D. P........Ft. Wayne, Ind.
McWhood, T. W....New York, N. Y.
McWhorter, J. P....Emporium, Pa.
McWhorter, M. J........Atlanta, Ga.
McWilliams, R. L...Greenfield, Mass.
Mead, C. A....Upper Montclair, N. J.
Mead, D. W...........Madison, Wis.
Mead, G. J.......W. Hartford, Conn.
Meade, L. P.......Bartlesville, Okla.
Meagher, F. J...Astoria, L. I., N. Y.
Mealand, A...........Elwood, Aust.
Means, F. W....Mountain Grove, Mo.
Meany, E. A.......Youngstown, Ohio
Meany, J. M..........Portland, Ore.
Mears, E.........Los Angeles, Calif.
Mears, E. W.........Philadelphia, Pa.
Mears, S. R.......Amsterdam, N. Y.
Medbery, E. W.........Chicago, Ill.
Medbery, R. L......Philadelphia, Pa.
Medcalf, L. C.....Mt. Vernon, N. Y.
Mede, J. J...........New York, N. Y.
Meeden, B. L....San Francisco, Calif.
Meeg, A. B.........Milwaukee, Wis.
Meehan, J..........Providence, R. I.
Meek, G. W............Beloit, Wis.
Meeker, W. H...........Ames, Iowa
Mees, R. T.............Peoria, Ill.
Meese, C. R...........Bradford, Pa.
Meglitz, W. B..........Berlin, N. H.
Meharg, L.........Wheeling, W. Va.
Mehlhope, L. E......Cincinnati, Ohio
Mehlig, T. P........Woodcliff, N. J.
Mehmel, L. E......Brooklyn, N. Y.
Mehrhof, F. E...New Brunswick, N. J.
Mehta, T. C..................
Narayanganj, Bengal, India
Meier, F..............Chicago, Ill.
Meili, G.........Los Angeles, Calif.
Meinholtz, E. C.......St. Louis, Mo.
Meissner, J. F..........Chicago, Ill.
Meixell, K. H.......Brooklyn, N. Y.
Mejo, E. O..Garden City, L. I., N. Y.
Mekler, L. A..........Chicago, Ill.
Melas, W............Philadelphia, Pa.
Melcher, C. W...................
Homosassa Springs, Fla.
Mele, T. W..........Baltimore, Md.
Melendy, J. G......New York, N. Y.
Melichar, J. T.Woodside, L. I., N. Y.
Melick, N. A......Washington, D. C.
Mellanby, A. L..................
Bridge-of-Weir, Scotland
Mellen, W. H.......N. Canton, Ohio
Mellowes, C. N.......Milwaukee, Wis.
Melrose, R. G. R...............
Buenos Aires, Argentina, S. A.
Melzig, A. H. J....Elizabethport, N. J.
Memory, N. H.........Newark, N. J.
Mendenhall, F.....Los Angeles, Calif.
Meneely, E. N.........Moscow, Idaho
Menkin, L..........New York, N. Y.
Menner, F. B..........St. Louis, Mo.
Menninges, M. B.......St. Louis, Mo.
Menon, V. K. A.......Trichur, India
Menshon, W. R.......Elizabeth, N. J.
Mensonides, S.........Buffalo, N. Y.
Menville, C. A.....Lake Charles, La.
Meny, J. W..........Hartford, Conn.
Menzl, L..........New York, N. Y.
Mercer, E. J..........Moscow, Idaho
Mercer, G. A., Jr......Savannah, Ga.
Merchant, M. E......Cincinnati, Ohio
Mercier, A. P.......Hartford, Conn.
Mercier, H. O.......New York, N. Y.
Mercier, S. M.......Winchester, Mass.
Mercner, R. O.......New York, N. Y.
Meredith, D.........Coalinga, Calif.
Meredith, W.....San Francisco, Calif.
Merkel, A. W......Birmingham, Ala.
Merkel, W. H.......Kansas City, Mo.
Merkle, R. W.........St. Louis, Mo.
Merkt, G. A.........Worcester, Mass.
Merkt, O. L.........New York, N. Y.
Merl, M. F............Atlanta, Ga.
Mero, R. M...........Seattle, Wash.
Merola, J. C.........New York, N. Y.
Merow, E. J......Cattaraugus, N. Y.
Merriam, C. F........Baltimore, Md.
Merriam, H. P....Hubbardston, Mass.
Merriam, K. G......Worcester, Mass.
Merriam, P. A.........Cranston, R. I.
Merrick, C. M., 3rd......Easton, Pa.
Merrifield, W.........New York, N. Y.
Merrill, A. P., Jr...Philadelphia, Pa.
Merrill, C. J..........Portland, Me.
Merrill, D. G.........Hartford, Conn.
Merrill, D. R....Los Angeles, Calif.
Merrill, E. I........Plainfield, N. J.
Merrill, E. N......Long Beach, Calif.
Merrill, G. H...Maspeth, L. I., N. Y.
Merrill, J. J............Chicago, Ill.
Merrill, J. L...................
Jackson Heights, L. I., N. Y.
Merrill, O. C......Washington, D. C.
Merrill, S. C.........Detroit, Mich.
Merring, H. L........New York, N. Y.
Merritt, H. W.......New York, N. Y.
Merritt, J...........Hartford, Conn.
Merritt, L. F..........Detroit, Mich.
Merritt, P. G., Jr...New Orleans, La.
Merry, H. G........Penns Grove, N. J.
Mersereau, T. T........Albany, N. Y.
Mershon, R. D..........Miami, Fla.
Mertens, F. M....Asbury Park, N. J.
Mervine, W. G.......New York, N. Y.
Merwin, H. H.........Kearny, N. J.
Merz, R. G...........New York, N. Y.
Mesinger, F. W.......Stamford, Conn.
Mesker, L. H.........Cleveland, Ohio
Messenger, R. P...Brussels, Belgium
Messer, R. E......Coulee Dam, Wash.
Messersmith, C. W....Lafayette, Ind.
Messersmith, E....Roselle Park, N. J.
Messinger, C. R........Chicago, Ill.
Messinger, J. P.......Cranford, N. J.
Messner, M...Great Neck, L. I., N. Y.
Meston, C. R..........Yonkers, N. Y.
Metcalf, F. H.........Holyoke, Mass.
Metcalf, G. R., Jr..........Erie, Pa.
Metcalf, I. R...........Chicago, Ill.
Metcalf, L. G.....Los Angeles, Calif.
Metcalf, S. C...........Chicago, Ill.
Metcalfe, W. K.....New York, N. Y.
Mettler, C. G..........Honolulu, T. H.
Metz, E. A............Glenarm, Md.
Metz, W. R.........Washington, D. C.
Metzner, B. C.......Elizabeth, N. J.
Meurling, I.........Marcus Hook, Pa.
Meyer, A...............Lincoln, Neb.
Meyer, A. D...........Endicott, N. Y.
Meyer, A. F.......Minneapolis, Minn.
Meyer, A. H..........Brooklyn, N. Y.
Meyer, A. I........Los Angeles, Calif.
Meyer, A. W.........Providence, R. I.
Meyer, C. A.........Philadelphia, Pa.
Meyer, C. F..........Wyomissing, Pa.
Meyer, C. W...........Baltimore, Md.
Meyer, E. C........Larchmont, N. Y.
Meyer, F. L..............Peoria, Ill.
Meyer, H. C., Jr....New York, N. Y.
Meyer, H. C. E.......New York, N. Y.
Meyer, H. F...........Cairo, Egypt
Meyer, H. J..........Milwaukee, Wis.
Meyer, I. L..........Philadelphia, Pa.
Meyer, J. A.............Newark, N. J.
Meyer, J. K............Louisville, Ky.
Meyer, P..............Newark, N. J.
Meyer, R. L............Whiting, Ind.
Meyer, R. M..........New York, N. Y.
Meyercord, G. R., Jr....Chicago, Ill.
Meyerhans, R. H...Schenectady, N. Y.
Meyers, E. C..........Hartford, Conn.
Meyers, F. H.......Brooklyn, N. Y.
Meyerson, M. H.......New York, N. Y.
Meyerstein, A. M.......Nutley, N. J.
Micallef, J. M.....Penns Grove, N. J.
Michael, J...........Wichita, Kan.
Michael, L. P...........Chicago, Ill.
Michal, E. B...Round Mountain, Nev.
Michel, A. E.........New York, N. Y.
Michel, J. R............Chicago, Ill.
Michel, L. R.......Cambridge, Mass.
Michel, M. P. H.....New Orleans, La.
Michel, R...............Towson, Md.
Michelena, J. L.Central Hershey, Cuba
Michelson, J. S........Wilton, Conn.
Mickle, R. T.........Philadelphia, Pa.
Micklethwaite, W. E...........
Toronto, Ont., Can.
Middlemiss, G. H...Birmingham, Ala.
Middleton, A. C.......Camden, N. J.
Middleton, C. W.....New York, N. Y.
Middleton, F. S.......Ramsey, N. J.
Middleton, L. H........Toledo, Ohio
Middleton, P. H.Wellesley Hills, Mass.
Midgette, E. L.......Baltimore, Md.
Midgley, Fred'k W..New York, N. Y.
Midgley, Fred'k W., Jr.........
New York, N. Y.
Miedendorp, H., Jr..Glen Rock, N. J.
Mierke, F. W.........Newark, N. J.
Miesel, C.....Elmhurst, L. I., N. Y.
Mihlstin, L. N.......New York, N. Y.
Mikels, J. W.......Springfield, Ohio
Mikeska, P. L...........Chicago, Ill.
Mikina, S. J.......E. Pittsburgh, Pa.
Miles, C. B............Omaha, Neb.
Miles, W. T.........New York, N. Y.
Milford, A. M.Long Island City, N. Y.
Miller, A. D............Agra, Okla.
Miller, A. H.........New York, N. Y.
Miller, A. R.......New York, N. Y.
Miller, A. S.........Princeton, N. J.
Miller, A. T.......New York, N. Y.
Miller, C. Arthur..Toronto, Ont., Can.
Miller, Clarence A.....Franklin, Pa.
Miller, C. E........Washington, D. C.
Miller, C. F.......Woonsocket, R. I.
Miller, C. G.........Bloomsburg, Pa.
Miller, C. L..........Brooklyn, N. Y.
Miller, D. E........Cincinnati, Ohio
Miller, Edw. Godfrey...Havana, Cuba
Miller, Ernest Geo..............
Soengei Gerong, Sumatra
Miller, E. W..........Hampton, Va.
Miller, F. J...........New Hope, Pa.
Miller, F. P...........Meadville, Pa.
Miller, F. R...............Troy, Ohio
Miller, F. S........Philadelphia, Pa.
Miller, F. W.......Philadelphia, Pa.
Miller, G. E.............Findlay, Ohio
Miller, H. A.......Springfield, Mass.
Miller, H. C. L., Jr...Richmond, Va.
Miller, H. E........Kansas City, Mo.
Miller, H. H........Harrison, N. J.
Miller, H. P., Jr.....New York, N. Y.
Miller, H. W........Ann Arbor, Mich.
Miller, J. Alfred.......Pelham, N. Y.
Miller, John Andrew.New York, N. Y.
Miller, J. F. G........Boston, Mass.
Miller, Jos. F. G..............
S. Charleston, W. Va.
Miller, J. G...........Detroit, Mich.
Miller, John M.........Chicago, Ill.
Miller, J. Melvin...Williamsport, Pa.
Miller, N...............Atlanta, Ga.
Miller, N. E..........Detroit, Mich.
Miller, N. L........Kansas City, Mo.
Miller, P. B..........Houston, Tex.
Miller, P. V.......Woonsocket, R. I.
Miller, Ralph.....Phillipsburg, N. J.
Miller, Roswell.....New York, N. Y.
Miller, Robt. A......Pittsburgh, Pa.
Miller, Roman A....Milwaukee, Wis.
Miller, Richard H...New Orleans, La.
Miller, Robt. H......Milwaukee, Wis.
Miller, R. R.....Port Ludlow, Wash.
Miller, R. W.......New York, N. Y.
Miller, Spencer, Jr..New York, N. Y.
Miller, Spencer, Sr.............
Laguna Beach, Calif.
Miller, S. C....San Francisco, Calif.
Miller, T. H.....Poughkeepsie, N. Y.
Miller, T. V...........Houston, Tex.
Miller, W..........Ponca City, Okla.
Miller, W. A..........Buffalo, N. Y.
Miller, W. B...Freeport, L. I., N. Y.
Miller, W. D..........New York, N. Y.
Miller, W. G., 3d..Los Angeles, Calif.
Miller, W. P.....Schenectady, N. Y.
Miller, W. R., Jr....North Wales, Pa.
Milligan, G. H., Jr..Upper Darby, Pa.
Millikan, C. B.......Pasadena, Calif.
Millikan, R. A.*.....Pasadena, Calif.
Millinger, W. A. F.Los Angeles, Calif.
Millington, H. C....Philadelphia, Pa.
Mills, Bernard..San Francisco, Calif.
Mills, Blake........Cambridge, Mass.
Mills, C. P.........Barcelona, Spain
Mills, E. A............London, Eng.
Mills, E. C...........Berkeley, Calif.
Mills, F.....Midland Junction, Aust.
Mills, F. S........Brookhaven, Miss.
Mills, Halstead H......Detroit, Mich.
Mills, Harold H.................
Long Island City, N. Y.
Millspaugh, G. A...Jersey City, N. J.
Millspaugh, W. H....Sandusky, Ohio
Milson, T. H............Paterson, N. J.
Miltenberger, G. K....St. Louis, Mo.
Minarik, R. G.......Berkeley, Calif.
Miner, H. L.......Philadelphia, Pa.
Miner, N. A.....Corpus Christi, Tex.
Ming, F. W..........Brooklyn, N. Y.
Miniberger, G. V....Milwaukee, Wis.
Minkema, W. H........Chicago, Ill.
Minor, B. S.........San Pedro, Calif.
Minot, F..............Boston, Mass.

* Non-Member.

Minton, O..........Greenwich, Conn.
Mirick, G. L.......Stoneham, Mass.
Mirovitch, E. B.......Brooklyn, N. Y.
Misch, C. E.........New York, N. Y.
Misener, C. C.......Worcester, Mass.
Mitcham, E. H......New York, N. Y.
Mitchell, A. E......New York, N. Y.
Mitchell, C. J. B.....Trenton, N. J.
Mitchell, C. O..........Glenside, Pa.
Mitchell, C. T......E. Orange, N. J.
Mitchell, D. H.........Needham, Mass.
Mitchell, F.....St. Marys, Ont., Can.
Mitchell, G. I.......Grove City, Pa.
Mitchell, H. C..............Erie, Pa.
Mitchell, H. F.........Glendale, Calif.
Mitchell, H. M.......St. Louis, Mo.
Mitchell, J. C. W..............
Campita, Venezuela, S. A.
Mitchell, J. F......Washington, D. C.
Mitchell, M. H......Cleveland, Ohio
Mitchell, N. T........Detroit, Mich.
Mitchell, R. B.....Little Rock, Ark.
Mitchell, R. C.....Springfield, Ohio
Mitchell, W. A.........Denver, Colo.
Mitchell, W. D..........Tulsa, Okla.
Mitchell, W. F.....Philadelphia, Pa.
Mitchell, W. G.........Chicago, Ill.
Mitchell, W. H..Niagara Falls, N. Y.
Mitsch, E. H........Cincinnati, Ohio
Mittendorf, W......Cincinnati, Ohio
Mixter, G. W.......New York, N. Y.
Miyakawa, T. S.....New York, N. Y.
Mjolsnes, E. L....Minneapolis, Minn.
Mochel, M. G.........Paulsboro, N. J.
Mock, R. M.......Los Angeles, Calif.
Mockridge, C. R.......Harrison, N. J.
Moebius, H. G......Stamford, Conn.
Moehrl, K. E...........Collins, Ga.
Moeller, W..............Dallas, Tex.
Moen, L............New York, N. Y.
Moen, L. W......E. Syracuse, N. Y.
Moffat, G. N..........Columbus, Ohio
Moffett, H. C..........Jackson, Mich.
Moffitt, R. C...........Seattle, Wash.
Mogensen, A. H......Westport, Conn.
Mohler, R. C.........Mt. Savage, Md.
Mohn, P. E..............Urbana, Ill.
Mohr, W. W.........E. Chicago, Ind.
Moksu, W. H..........Boston, Mass.
Mole, H. E............Summit, N. J.
Moler, F. W., Jr...Crestwood, N. Y.
Molinari, W. H.....Wilmington, Del.
Moline, A. A.........Pittsburgh, Pa.
Moller, H. F..........Houston, Tex.
Moller, J. A............Chicago, Ill.
Molleson, G. C.......Richmond, Va.
Molloy, F. G..........London, Eng.
Molnar, E..........Columbus, Ohio
Molokie, S. W....Staten Island, N. Y.
Molony, N. J.......New York, N. Y.
Molter, F. H........New York, N. Y.
Momberger, W. J.......Orange, N. J.
Monro, D. A............Chicago, Ill.
Monroe, E. T........Cameron, W. Va.
Monroe, F. A., Jr....New York, N. Y.
Monroe, W. S............Chicago, Ill.
Monsell, J. R.......Philadelphia, Pa.
Montague, C. E.......Syracuse, N. Y.
Montague, E. N....Washington, D. C.
Montague, J. F......Audubon, N. J.
Montanes, C. E............Madrid, Spain
Montgomery, G. L....New York, N. Y.
Montgomery, O. C..New York, N. Y.
Montgomery, T. R..Woods Hole, Mass.
Montgomery, W...Morris Plains, N. J.
Montgomery, W. J...Brockton, Mass.
Montoro, A. A.......Coatesville, Pa.
Moodie, A............Norwich, Conn.
Moodie, T. E............Atlanta, Ga.
Moodie, W. C.......Montclair, N. J.
Moody, A. M. G.......Newark, Del.
Moody, C. F.........Yonkers, N. Y.
Moody, H. A.....Turners Falls, Mass.
Moody, H. N.........New Orleans, La.
Moody, L. F..........Philadelphia, Pa.
Moody, R. C.........Stamford, Conn.
Moody, V. D.........New York, N. Y.
Moody, W. F., Jr.......Raleigh, N. C.
Moody, W. M.........Berkeley, Calif.
Moolhuysen, T..............Lodi, N. J.
Mooney, D. A..........Fall River, Mass.
Mooney, G. M........St. Paul, Minn.
Mooney, J. D.......New York, N. Y.
Mooney, W..........Kansas City, Mo.
Moore, A. F......Coulee Dam, Wash.
Moore, C. F., Jr..San Francisco, Calif.
Moore, C. Herbert..Lake Forest, Ill.
Moore, Chas. H.........Lenape, Pa.
Moore, D............New York, N. Y.
Moore, F. C...........Canton, Ohio
Moore, F. E.......Ellwood City, Pa.
Moore, F. H............Boston, Mass.
Moore, F. L............Scranton, Pa.
Moore, H. E............Franklin, Pa.
Moore, H. F..............Urbana, Ill.
Moore, H. H........New York, N. Y.
Moore, H. T........Philadelphia, Pa.

Moore, J. C. S....Chatham, Ont., Can.
Moore, J. E........Hutchinson, Kan.
Moore, J. T..........Shreveport, La.
Moore, J. W.......Birmingham, Ala.
Moore, L. C..............Tulsa, Okla.
Moore, M. F...........Kewanee, Ill.
Moore, M. J. P................ Albuquerque, New Mex.
Moore, R. A........Wenatchee, Wash.
Moore, R. D.........Columbus, Ohio
Moore, R. P............Buffalo, N. Y.
Moore, T. I..........Columbus, Ohio
Moore, T. J................. Jackson Heights, L. I., N. Y.
Moore, W. A.....Welland, Ont., Can.
Moore, W. D........Birmingham, Ala.
Moore, W. E.........Pittsburgh, Pa.
Moore, Wm. H................ Woodbury Heights, N. J.
Moore, Wm. Henry....Hanover, N. H.
Moore, W. Joe......Birmingham, Ala.
Moore, Wm. James...Brooklyn, N. Y.
Moore, W. R............Atlanta, Ga.
Moore, W. T.........New York, N. Y.
Moorehead, D. G....New York, N. Y.
Moores, R. de la H............ San Francisco, Calif.
Moorhouse, M....Calgary, Alta., Can.
Morales, P. C..........Mexico, Mex.
Moran, D. E.........New York, N. Y.
Moran, W. L........S. Newport, Ky.
Moran, W. R...........Warsaw, Ind.
Morat, J..............Tassin, France
Morden, C. W.........Portland, Ore.
Morehead, F. H.....New York, N. Y.
Morehead, G. L.....Philadelphia, Pa.
Morehouse, J. S.......Villanova, Pa.
Moreinis, D.........New York, N. Y.
Moreland, E. L.........Boston, Mass.
Moreton, J. B.......Rochester, N. Y.
Morey, A. A.............Chicago, Ill.
Morey, C. T.......Providence, R. I.
Morgan, A. B......New York, N. Y.
Morgan A. Hedley.London, Ont., Can.
Morgan, Albert H...New York, N. Y.
Morgan, D. K.......Hartford, Conn.
Morgan, D. R.......Des Moines, Iowa
Morgan, D. W. R....Philadelphia, Pa.
Morgan, E. K..........Rockford, Ill.
Morgan, G. R......Greenville, S. C.
Morgan, H. H..........Chicago, Ill.
Morgan, I. N. R.......Baltimore, Md.
Morgan, J. D.....South Orange, N. J.
Morgan, J. L.....Los Angeles, Calif.
Morgan, J. T.....Charleston, W. Va.
Morgan, P. B.......Worcester, Mass.
Morgan, T. A........New York, N. Y.
Morgan, V. D...........Chicago, Ill.
Morgenroth, R. J....Christiana, Pa.
Morhardt, F. W......Hartford, Conn.
Morin, L. H.........New York, N. Y.
Morin, R. P.......Manchester, N. H.
Moritz, A. J. L..........Enka, N. C.
Moritz, H. K..........Seattle, Wash.
Morlan, E. A.........Gunnison, Colo.
Morley, M. D.......New York, N. Y.
Morrell, M. C.........Sidney, N. Y.
Morrill, T. L., Jr......Oakland, Calif.
Morris, B. F.......W. Orange, N. J.
Morris, E. A.........Brooklyn, N. Y.
Morris, J. A.........Hartsdale, N. Y.
Morris, J. D............Orange, N. J.
Morris, J. K..........Seattle, Wash.
Morris, R. H............Chicago, Ill.
Morris, T. B.........Cincinnati, Ohio
Morris, T. C.........Hopewell, Va.
Morris, W. Cullen...New York, N. Y.
Morris, Wm. Chester..Buffalo, N. Y.
Morris, W. S........Cincinnati, Ohio
Morrish, M............Toronto, Can.
Morrison, E. G...........Chicago, Ill.
Morrison, E. L............Akron, Ohio
Morrison, J. P.........Hartford, Conn.
Morrison, L. H................ Port Washington, L. I., N. Y.
Morrison, M..Upper Montclair, N. J.
Morrison, W. B.......Spokane, Wash.
Morrison, W. S....New York, N. Y.
Morriss, A. D..Washingtonville, N. Y.
Morrissey, J. P....New York, N. Y.
Morrissey, P. J..New Rochelle, N. Y.
Morrow, J. H......Catasauqua, Pa.
Morrow, L. C.......New York, N. Y.
Morrow, L. W. W....Corning, N. Y.
Morrow, R. L........New York, N. Y.
Morse, A. E............Alpena, Mich.
Morse, A. H.........Cincinnati, Ohio
Morse, C. H............Chicago, Ill.
Morse, C. K.........Plainfield, N. J.
Morse, E. P................ W. New Brighton, S. I., N. Y.
Morse, F. T......Charlottesville, Va.
Morse, H. S..........St. Louis, Mo.
Morse, J. W..........Lansing, Mich.
Morse, Louis S., Jr.....Chicago, Ill.
Morse, Louis S., Sr.........York, Pa.
Morse, R. H............Chicago, Ill.
Morse, R. V............Ithaca, N. Y.
Morss, C. A.......W. Hartford, Conn.
Mortimer, J. D...........Belfast, Me.
Morton, A. B.....Castlemaine, Aust.
Morton, A. W...........Baltimore, Md.
Morton, G. L......Washington, D. C.
Morton, H. S......Minneapolis, Minn.
Morton, Q. L......New York, N. Y.
Morton, R. W..........Golden, Colo.
Mosbrook, J. S....Wilmington, Del.
Moseley, A. W.......Swarthmore, Pa.
Moses, A. S........New York, N. Y.
Moses, E. B..........Denver, Colo.
Moses, F. C........New York, N. Y.
Moses, F. T.........Providence, R. I.
Mosher, F. D.........Brooklyn, N. Y.
Moshkoff, S. V.....Milledgeville, Ga.
Mosler, A. R., Jr....Cumberland, Md.
Moss, H. H.........New York, N. Y.
Moss, S. A..........W. Lynn, Mass.
Mossberg, F.........Attleboro, Mass.
Motheral, H. H....New York, N. Y.
Mott, C. J..........Elizabeth, N. J.
Mott, C. S............Detroit, Mich.
Mott, E. P...........Brooklyn, N. Y.
Mouat, H. G........Birmingham, Ala.
Mould, A. E.........New York, N. Y.
Moulder, A. W.....Providence, R. I.
Moulton, C. F...........Omaha, Neb.
Moulton, M. V....Los Angeles, Calif.
Moultrop, I. E.......Belmont, Mass.
Mount, R. H...........Detroit, Mich.
Mowat, J. F.............Chicago, Ill.
Mowatt, W. T..San Francisco, Calif.
Mowry, C. W...........Boston, Mass.
Moxham, E...........New York, N. Y.
Moxley, S. D......Birmingham, Ala.
Moy, S...............Portland, Ore.
Moyer, A. F.......Minneapolis, Minn.
Moyer, J. A...........Boston, Mass.
Moyer, J. O............Fitzgerald, Ga.
Moyer, M. B..........Syracuse, N. Y.
Moyer, R. E., Jr......Allentown, Pa.
Muchnic, C. M.......New York, N. Y.
Mudd, J. P........Philadelphia, Pa.
Mudge, R. S........New York, N. Y.
Mudge, S. W.........New York, N. Y.
Mueller, C. F........Cleveland, Ohio
Mueller, F. J.........West Allis, Wis.
Mueller, H. G..............Erie, Pa.
Mueller, K. W......Brooklyn, N. Y.
Mueller, L. W...........Decatur, Ill.
Mueller, M. W.........Saginaw, Mich.
Mueller, P. M...........Rome, N. Y.
Mueller, V. H.......New York, N. Y.
Mueller, W. C...........Chicago, Ill.
Muerle, R. W.........Springfield, Ill.
Muessel, C. A.........Pelham, N. Y.
Muhlethaler, R., Jr....Newark, N. J.
Muhlfeld, J. E.......New York, N. Y.
Muhlig, J. R......Old Hickory, Tenn.
Muhlsteff, R. P.....New York, N. Y.
Muir, J. F..........New York, N. Y.
Muir, M.............New York, N. Y.
Muir, R. C........Schenectady, N. Y.
Muldaur, G. B......New York, N. Y.
Mule, A.....Long Island City, N. Y.
Mulert, J. L..........Pittsburgh, Pa.
Mullee, W. R..........Butler, N. J.
Mullen, B. J.........Dearborn, Mich.
Mullen, C. A..........Brooklyn, N. Y.
Mullen, T. J., Jr..Washington, D. C.
Muller, A............New York, N. Y.
Muller, D. C.........Cincinnati, Ohio
Muller, D. L.........New York, N. Y.
Muller, E. A.........Cincinnati, Ohio
Muller, E. S.........Naugatuck, Conn.
Muller, F. G. D.........Houston, Tex.
Muller, J.................Chicago, Ill.
Muller, O..........Southbridge, Mass.
Muller, O. W.............Houston, Tex.
Muller, R. A............Boston, Mass.
Muller, R. F.........New Orleans, La.
Muller, R. O..........Hartford, Conn.
Muller, R. W..........Sewaren, N. J.
Muller, V..........Washington, D. C.
Mullergren, A. L....Kansas City, Mo.
Mullhaupt, A., Jr.......Bradford, Pa.
Mulligan, J. E.....Cambridge, Mass.
Mulligan, P. B......New York, N. Y.
Mullikin, H. F.......New York, N. Y.
Mullin, M...........New Ulm, Minn.
Mullins, E. E............Havana, Cuba
Mullowney, P. F.......Trenton, N. J.
Mulrey, M. D............Peoria, Ill.
Mulrooney, A. J....Philadelphia, Pa.
Mumford, A. R......New York, N. Y.
Mummert, H. B...........Chicago, Ill.
Mummery, C. R....N. Canton, Ohio
Munier, L. L.....New York, N. Y.
Munn, H. T..........Chicago, Ill.
Munns, J. J...........Weirton, W. Va.
Munro, G. W.......W. Lafayette, Ind.
Munro, R. W.........Philadelphia, Pa.
Munroe, E. K.........Baltimore, Md.
Munroe, H. F.....New Haven, Conn.
Munroe, H. S....Toronto, Ont., Can.
Munschauer, G. R......Buffalo, N. Y.
Munson, E. G...........Utica, N. Y.
Munson, J. G.....Rogers City, Mich.
Munson, S.........Hollis, L. I., N. Y.
Muntz, P..............Portland, Ore.
Munzinger, F......Berlin, Germany
Murch, S..............Detroit, Mich.
Murphy, B. S.......New York, N. Y.
Murphy, E. F., Jr.Painted Post, N. Y.
Murphy, E. T...........Chicago, Ill.
Murphy, G. F.........Newark, N. J.
Murphy, H. C.........Louisville, Ky.
Murphy, R. E.Long Island City, N. Y.
Murphy, R. J.........Brooklyn, N. Y.
Murphy, T. R. H....Ridgefield, Conn.
Murphy, W. B........Philadelphia, Pa.
Murphy, W. J.........Newark, N. J.
Murray, A. F......E. Pittsburgh, Pa.
Murray, C. P...........Elma, Wash.
Murray, E. D........Oakland, Calif.
Murray, F. F............Dallas, Tex.
Murray, G. J., Jr.Baldwin, L. I., N. Y.
Murray, J. A...........Denver, Colo.
Murray, J. O'H.........London, Eng.
Murray, T. E., Jr...New York, N. Y.
Murray, W. E...San Francisco, Calif.
Murray, W. F........Coldwater, Mich.
Murray, W. H. G....Syracuse, N. Y.
Murray, W. M.....Cambridge, Mass.
Murty, T. B. N....Jamshedpur, India
Muscarell, R. V....New York, N. Y.
Muschenheim, F. A..New York, N. Y.
Musso, A...............Troy, N. Y.
Muthuswami, S.....Bangalore, India
Mutimer, A. G.........Detroit, Mich.
Muzik, V. K..Prague, Czechoslovakia
Myers, A. H...........Albany, N. Y.
Myers, C. C..Long Island City, N. Y.
Myers, C. O........Columbus, Ohio
Myers, D. M.........New York, N. Y.
Myers, F. M....Woodside, L. I., N. Y.
Myers, G. S., Jr..Chattanooga, Tenn.
Myers, H. G......El Segundo, Calif.
Myers, J............New York, N. Y.
Myers, M. E..........Portland, Ore.
Myers, R. D.......Jeffersonville, Ind.
Myers, T. G......Los Angeles, Calif.
Myers, W. J..........Millerton, N. Y.
Myers, W. K......Philadelphia, Pa.
Myhre, E. B......Sioux Falls, S. D.
Mylroie, J. E.........Seattle, Wash.
Mynderse, C. N.....Knoxville, Tenn.

N

Nachman, H. L.........Chicago, Ill.
Nadai, I. A........Wilkinsburg, Pa.
Nadler, R. A........Plaquemine, La.
Nagel, C.........Los Angeles, Calif.
Nagel, T..........Brooklyn, N. Y.
Nagler, F.........Toronto, Ont., Can.
Naiman, J. M..........Detroit, Mich.
Nance, G. R......Los Angeles, Calif.
Napier, A. E.......Brooklyn, N. Y.
Napp, J. L..........Brooklyn, N. Y.
Nardin, C. F..Ozone Park, L. I., N. Y.
Nardone, R. M....E. Orange, N. J.
Naromore, G. C........Boston, Mass.
Nash, D. E.......S. Norwalk, Conn.
Nash, R. K........Cambridge, Mass.
Nash, R. L........Wilmerding, Pa.
Nash, W. W............Aurora, Ill.
Nathan, H. H.......Charleston, S. C.
Naughton, F. U., Jr.Worcester, Mass.
Naugle, J. J......New York, N. Y.
Naumann, C......Philadelphia, Pa.
Naumburg, R. E...New York, N. Y.
Naylor, F. L., Jr.......Vernon, Calif.
Naylor, G. M.......New York, N. Y.
Naylor, J. W....Niagara Falls, N. Y.
Neal, G. A.........Sioux City, Iowa
Neal, J. R. H..........Buffalo, N. Y.
Neal, R. S.............Chicago, Ill.
Neal, S...........Schenectady, N. Y.
Neale, J. A...........Chicago, Ill.
Nearing, D. W......Cincinnati, Ohio
Neave, P. M.........New York, N. Y.
Nebesar, R. J..Prague, Czechoslovakia
Nederman, M. R....Brooklyn, N. Y.
Neeb, E. A..........Johnstown, Pa.
Needham, H. H......Milwaukee, Wis.
Needham, H. S........Passaic, N. J.
Needham, R. J....Toronto, Ont., Can.
Needham, W. H.....Monrovia, Calif.
Needs, S. J.........Philadelphia, Pa.
Needy, J. A..............Ada, Ohio
Neefus, J. L................ Rockaway Beach, L. I., N. Y.
Neel, R. W............Atlanta, Ga.
Neely, F. H...........Atlanta, Ga.
Neely, W. J..........Freeport, Ill.
Neff, E. H.........New York, N. Y.
Neff, J. I.............Seattle, Wash.
Neff, J. P.........New York, N. Y.
Neidig, W. N......New York, N. Y.
Neil, E. B.............Detroit, Mich.
Neiler, S. G............Chicago, Ill.
Neill, W. A.........Harrison, N. J.
Neilson, E. J.........Brooklyn, N. Y.
Neilson, F. C........Hartford, Conn.
Neilson, W. J........Mineola, N. Y.
Neiva, R. V................ Rio de Janeiro, Brazil, S. A.
Nelden, R. M..Salt Lake City, Utah
Nelis, J. J...........Brooklyn, N. Y.
Nelson, A. J................ Port Richmond, S. I., N. Y.
Nelson, A. L..........Boston, Mass.
Nelson, B. S........New Orleans, La.
Nelson, D. W..........Madison, Wis.
Nelson, E. A..St. Clair Shores, Mich.
Nelson, E. F........Hartford, Conn.
Nelson, E. H.........Massillon, Ohio
Nelson, G. H......Rochester, N. Y.
Nelson, H. A...........Buffalo, N. Y.
Nelson, H. F...........Detroit, Mich.
Nelson, H. I. R..Port Chester, N. Y.
Nelson, J. F.......Chattanooga, Tenn.
Nelson, M. A.......Philadelphia, Pa.
Nelson, M. R..........Denver, Colo.
Nelson, P. C........New York, N. Y.
Nelson, R. A................ International Falls, Minn.
Nelson, R. H............Moline, Ill.
Nelson, R. T.........Ft. Worth, Tex.
Nelson, S. C.........Brooklyn, N. Y.
Nelson, S. W..........Buffalo, N. Y.
Nelson, W. A..........Newark, N. J.
Nelson, W. S.......New Orleans, La.
Nemec, E. J......Minneapolis, Minn.
Nenninger, L. F.....Cincinnati, Ohio
Nerad, A. J......Schenectady, N. Y.
Nesbit, E...........Cleveland, Ohio
Nesbit, J. N. G....College Park, Md.
Nesbitt, E. J..........Murphy, N. C.
Nesbitt, H..........New York, N. Y.
Nesson, I...............Lynn, Mass.
Nestel, H. A....Stuttgart, Germany
Nestler, P. J.......New York, N. Y.
Netherwood, J. S......Houston, Tex.
Netzer, P. M.............Laredo, Tex.
Neu, H. J. E............Lille, France
Neubauer, G. A........Buffalo, N. Y.
Neuburger, H. R....New York, N. Y.
Neuhaus, F..........Berlin, Germany
Neuhaus, R...........Houston, Tex.
Neumann, A.........New York, N. Y.
Neumann, A. E..........Chicago, Ill.
Neumunz, M........New York, N. Y.
Neureuther, A. H..........Peru, Ill.
Neuschafer, G. A.....Brooklyn, N. Y.
Nevill, G. E...........Houston, Tex.
Nevins, E..............El Paso, Tex.
New, W. E.........Kansas City, Mo.
Newbold, J. D., Jr..Philadelphia, Pa.
Newbold, R. S...Atlantic City, N. J.
Newbury, F. D....E. Pittsburgh, Pa.
Newcomb, E. C....N. Scituate, Mass.
Newcomb, F. L..........Roselle, N. J.
Newcomb, R. E......Holyoke, Mass.
Newcomb, R. S..........Atlanta, Ga.
Newell, F. M..........Newport, Del.
Newell, F. T........New York, N. Y.
Newell, H. B.........Cleveland, Ohio
Newell, J. B........Seminole, Okla.
Newell, J. C.............Peoria, Ill.
Newell, R. L..........Blossburg, Pa.
Newell, T. A...........Newark, N. J.
Newell, W.........New York, N. Y.
Newell, W. L..........Seattle, Wash.
Newhall, E. A.......Philadelphia, Pa.
Newhall, W. L.........Pittsburgh, Pa.
Newhouse, R. C.....Milwaukee, Wis.
Newill, G. E....Montreal, Que., Can.
Newkirk, B. L...Schenectady, N. Y.
Newman, P. F.....New York, N. Y.
Newman, S. F.......Waynesboro, Pa.
Newman, S. M.....Washington, D. C.
Newport, V. G................ Forest Hills, L. I., N. Y.
Newstrom, C. L.......Seattle, Wash.
Newton, A. B.....Minneapolis, Minn.
Newton, C. V..San Luis Obispo, Calif.
Newton, E. K....Niagara Falls, N. Y.
Newton, N. A............Oil City, Pa.
Newton, W. G.....New Haven, Conn.
Nexsen, R. H.......New York, N. Y.
Nibbs, E.........New London, Conn.
Nibecker, K..............Cicero, Ill.
Nicastro, G. J.......New York, N. Y.
Niccolls, R. S...San Francisco, Calif.
Nicholas, S.........New York, N. Y.
Nicholls, P............Pittsburgh, Pa.
Nichols, DeO., Jr........Peoria, Ill.
Nichols, E. B......Moorestown, N. J.
Nichols, G. B..........Kingston, R. I.
Nichols, H. J..........Downey, Cal.
Nichols, J. H....Pearl Harbor, T. H.
Nichols, O...............Chicago, Ill.
Nichols, W. H.Great Neck, L. I., N. Y.
Nichols, W. M..........Auburn, N. Y.
Nichols, Wm. Wallace.......... New York, N. Y.

Nichols, Wm. Westervelt.......
Detroit, Mich.
Nicholson, E. K.......Buffalo, N. Y.
Nicholson, R., Jr...W. Orange, N. J.
Nicholson, S. T.....Wilkes-Barre, Pa.
Nickel, A. A...........Toledo, Ohio
Nickerson, A. T..Jamaica, L. I., N. Y.
Nickerson, J. W...Manchester, Conn.
Nicklin, E. W.........Detroit, Mich.
Nicol, G. A., Jr.....New York, N. Y.
Nicol, H. E.........Milwaukee, Wis.
Nicol, N. C.........New York, N. Y.
Nicolai, A. L.......New York, N. Y.
Nicolai, G.............Habana, Cuba
Nicoletti, G. W.......Detroit, Mich.
Nicolich, M. J....Jersey City, N. J.
Nicolson, G. F....Los Angeles, Calif.
Niebanck, R. J., Jr......Ivanhoe, Va.
Niederauer, H. H....Columbus, Ind.
Niederauer, W. J.....Yonkers, N. Y.
Niederman, P. H......Oak Park, Ill.
Nielsen, H. K.......New York, N. Y.
Nielsen, J....Mariners Harbor, N. Y.
Nielsen, S. G.......Philadelphia, Pa.
Niemeyer, E. A.....New York, N. Y.
Niemi, L. S...........St. Louis, Mo.
Niemitz, G.........New York, N. Y.
Niessing, W. J......New York, N. Y.
Nigh, G. W.........Bayonne, N. J.
Nikazy, C. N.........Seattle, Wash.
Nikoloff, S..........Worcester, Mass.
Nikonow, J. P......New York, N. Y.
Niles, A. S.Stanford University, Calif.
Nilson, J. H.........Pittsburgh, Pa.
Nimbkar, V..........Bombay, India
Niper, L. S..........Brooklyn, N. Y.
Nisbet, G. P........Wilkinsburg, Pa.
Nisbet, R. A......Schenectady, N. Y.
Nitschke, C. R......New York, N. Y.
Nixon, B...............Akron, Ohio
Nixon, W..........Knoxville, Tenn.
Noack, H. W. L.......Detroit, Mich.
Noble, E. W.....Niagara Falls, N. Y.
Noble, G.........Sarnia, Ont., Can.
Noble, K. B.........Hartford, Conn.
Noble, R. E.........Pittsburgh, Pa.
Noble, W. J., Jr...New Britain, Conn.
Noell, M. J.............Dallas, Tex.
Nofsinger, L. E........Orange, N. J.
Nohse, W. R. E.....Elizabeth, N. J.
Nolan, C. C...........Seattle, Wash.
Noland, R. C....San Francisco, Calif.
Nolde, A. M.................
Richmond Hill, L. I., N. Y.
Nolte, C. B............Chicago, Ill.
Noltimier, F. H...Los Angeles, Calif.
Nones, L. W........New York, N. Y.
Nonnenbruch, O....New York, N. Y.
Noonan, J. D..........Boston, Mass.
Norcross, J. A.....New Haven, Conn.
Nordberg, B. V. E...Milwaukee, Wis.
Nordberg, C. V.........Butte, Mont.
Norden, H. F.......New York, N. Y.
Nordenholt, G. F...New York, N. Y.
Nordheimer, A......New York, N. Y.
Nordin, J. A.......Finspong, Sweden
Nordlinger, S. G...Washington, D. C.
Nordstrom, E.........Newark, N. J.
Nordstrom, R. F.Lynbrook, L. I., N. Y.
Nordt, P. W., Jr....E. Orange, N. J.
Norling, B. S..........Neenah, Wis.
Norman, C. A.......Columbus, Ohio
Norman, E. E......Kalamazoo, Mich.
Norman, F. J.......Manhattan, Kan.
Norman, R. A............Ames, Iowa
Normandin, C. A.....San Jose, Calif.
Normile, T. H......New York, N. Y.
Norris, A. G.........Hoboken, N. J.
Norris, A. M.........Baltimore, Md.
Norris, C. B.....Grand Rapids, Mich.
Norris, C. D.......New York, N. Y.
Norris, C. H......New Britain, Conn.
Norris, E. B.........Blacksburg, Va.
Norris, E. R.........Pittsburgh, Pa.
Norris, E. W..........Boston, Mass.
Norris, H. L........New York, N. Y.
Norris, J. A...........Temple, Tex.
Norris, J. B., Jr......Baltimore, Md.
Norris, R. H......Schenectady, N. Y.
North, R. A.......New Haven, Conn.
Northam, C. D..........Chicago, Ill.
Northcliffe, L. C........Chicago, Ill.
Northfield, G. H..Minneapolis, Minn.
Northrup, F. B........Nutley, N. J.
Northrup, M. G...Los Angeles, Calif.
Northup, W C......Greenwood, R. I.
Norton, A. E.......Cambridge, Mass.
Norton, A. W........Baltimore, Md.
Norton, C. H......Plainville, Conn.
Norton, C. L.......Cambridge, Mass.
Norton, G. H.........Guilford, Conn.
Norton, P. T., Jr.....Backsburg, Va.
Norvig, I. E..........Stamford, Conn.
Norvig, J...........Hartsdale, N. Y.
Noss, O. F......W. Englewood, N. J.
Nott, A. J..........New York, N. Y.
Novak, M. M..........Geneva, Ohio
Novikoff, I. A.........Hopewell, Va.
Novotny, K. A......New York, N. Y.
Noxon, E. W..........St. Louis, Mo.
Noyes, G. E.......Sacramento, Calif.
Noyes, H. T.......Rochester, N. Y.
Noyes, J. A.............Dallas, Tex.
Noyes, M. S.......Washington, D. C.
Noyes, R. W..........Oneida, N. Y.
Noyes, W...........Lancaster, Pa.
Nugent, C. D...........Chicago, Ill.
Nugent, E. L.........Detroit, Mich.
Nugey, A. L.........Rahway, N. J.
Null, C. R.............Lorain, Ohio
Nulle, J. H......Corona, L. I., N. Y.
Nulsen, J. C...........Chicago, Ill.
Nulsen, M. E.......Indianapolis, Ind.
Nunn, P. N.....Salt Lake City, Utah
Nunnally, P.........Pine Bluff, Ark.
Nusim, M. J............Easton, Pa.
Nussbaum, L.......Philadelphia, Pa.
Nute, E. L...........Malden, Mass.
Nutt, H. V...........Allston, Mass.
Nydegger, P. F...Elizabethport, N. J.
Nye, R. G......N. Tonawanda, N. Y.
Nyffeler, O. W......Peekskill, N. Y.
Nygaard, K. C..........Chicago, Ill.
Nygren, K. A.......Milwaukee, Wis.
Nystrom, K. F......Milwaukee, Wis.

O

Oakes, W. H...........Boston, Mass.
Oakland, B.............Monroe, La.
Oakley, A. W......New York, N. Y.
Oatley, H. B........New York, N. Y.
Oatley, H. C...Bellerose, L. I., N. Y.
Oakley, W. B., Jr.....Detroit, Mich.
Oaks, R. M.........Pasadena, Calif.
O'Bannon, L. S.......Lexington, Ky.
Ober, P. L.........Worcester, Mass.
Ober, T. M...........Portland, Ore.
Oberg, E..........New York, N. Y.
Oberg, H. V..........Lancaster, Pa.
Oberg, W. O.........Pittsburgh, Pa.
Obergfell, H. F........Chicago, Ill.
Oberholzter, P. N...Philadelphia, Pa.
Oberholtzer, R. E....Bridgeport, Pa.
Oberhuber, W. F....Philadelphia, Pa.
Oberlin, E. G.....Washington, D. C.
Oberlink, B. S......Milwaukee, Wis.
Obermanns, H. E..........Erie, Pa.
Obert, C. W........New York, N. Y.
Oberst, D. A.......Perrysburg, Ohio
O'Brien, E. M.......Ridley Park, Pa.
O'Brien, E. W..........Atlanta, Ga.
O'Brien, F. R........Billings, Mont.
O'Brien, F. L., Jr...Philadelphia, Pa.
O'Brien, I. K.......Ridley Park, Pa.
O'Brien, J. E..........Chicago, Ill.
O'Brien, J. K.......Philadelphia, Pa.
O'Brien, L. J.......Rochester, N. Y.
O'Brien, M. P........Berkeley, Calif.
O'Brien, P. J...........Rutland, Vt.
O'Brien, R. D..........Butte, Mont.
Obrig, A............Cleveland, Ohio
O'Bryan, G. C.......Lewiston, Idaho
O'Callaghan, F. T.............
N. Tarrytown, N. Y.
O'Callaghan, J.................
Rio de Janeiro, Brazil, S. A.
Ochs, S. A..........Ossining, N. Y.
Ochtman, L., Jr........Bradford, Pa.
O'Conor, F..........Rock Island, Ill.
Odbert, J. T........Cleveland, Ohio
Ode, R. T..........Providence, R. I.
Odell, LeR. L......New York, N. Y.
Odenath, H. E.....Philadelphia, Pa.
O'Donnell, L..........Houston, Tex.
Oederlin, F..Winterthur, Switzerland
Oehrli, J. W.......Williamsport, Pa.
Oelkers, A. L....Huntington, W. Va.
Oergel, C. T..............Erie, Pa.
Oertel, G.........Mare Island, Calif.
Oesterle, P. D......Philadelphia, Pa.
Oestnaes, V. L.......Elizabeth, N. J.
Oetinger, G., Jr.........Norfolk, Va.
Offenheiser, C. M.....Brooklyn, N. Y.
Offer, L. A.........Detroit, Mich.
Officer, W. J..........Clinton, Mass.
Ogawa, Y.......Los Angeles, Calif.
Ogden, J. B........New York, N. Y.
Ogden, N..........Philadelphia, Pa.
Ogden, W. B..........Chicago, Ill.
Ogur, E............Belleville, N. J.
O'Hara, J. P.......Hazel Crest, Ill.
O'Hart, T. C........Cleveland, Ohio
Ohle, E. L............St. Louis, Mo.
Ohler, N. R............Toledo, Ohio
Ohler, R. E.......Kansas City, Mo.
Ohlson, C. A.......Lyndhurst, N. J.
Ohmer, P. H......Youngstown, Ohio
Ohmes, A. K.......New York, N. Y.
Ohren, G. A.......New York, N. Y.
Oill, B. C.........Brooklyn, N. Y.
O'Keefe, G. F....New London, Conn
Okey, P..............Columbus, Ohio
Okner, B. S............Chicago, Ill.
Oksen, H. C.......Menominee, Mich.
Oldham, E. L........Cleveland, Ohio
Oldham, P. T........Coatesville, Pa.
Olditch, F. W.................
Alta-Gracia, Argentina, S. A.
O'Leary, D...........Seattle, Wash.
O'Leary, J. J.........Hopewell, Va.
O'Leary, P. C..........Chicago, Ill.
Oleksiw, J............Ithaca, N. Y.
Olesen, T. C..........Detroit, Mich.
Oliker, H...........Brooklyn, N. Y.
Olin, F. W................Alton, Ill.
Olin, S. T................Alton, Ill.
Olind, J. H.........Stamford, Conn.
Oliphant, J. J.....Bakersfield, Calif.
Olive, R. W.........Charlotte, N. C.
Olive, T. R.........New York, N. Y.
Oliver, B. H., Jr....Brooklyn, N. Y.
Oliver, C. B...........Havana, Cuba
Oliver, E. C...........Adrian, Mich.
Oliver, F. J., Jr.......Detroit, Mich.
Oliver, H. G., Jr........Leonia, N. J.
Olivetti, A..............Ivrea, Italy
Olley, M ....Detroit, Mich.
Olofson, E. C......New York, N. Y.
Olschwang, M. J....Brooklyn, N. Y.
Olsen, G. E........New York, N. Y.
Olsen, H. B........New York, N. Y.
Olsen, O. LaC..........Tulsa, Okla.
Olson, C. G............Chicago, Ill.
Olson, C. J............Lincoln, Neb.
Olson, C. W.........Cleveland, Ohio
Olson, D. L..............Quincy, Ill.
Olson, E...........Honolulu, T. H.
Olson, E. W..........Andover, Mass.
Olson, Malven L....Indianapolis, Ind.
Olson, Martin L........Boston, Mass.
Olson, R. A............Chicago, Ill.
Olson, R. G., Jr.............
Muskegon Heights, Mich.
Olson, R. V.........Attleboro, Mass.
Olsson, C. D..........Passaic, N. J.
Olt, R. G..............Chicago, Ill.
Oltean, G.............Detroit, Mich.
Olver, A. S.......Toronto, Ont., Can.
O'Malley, J. F.........Scranton, Pa.
O'Malley, W. J....Manchester, N. H.
Oman, G. E.........Windham, Conn.
O'Mara, R. F..........Chicago, Ill.
Onderdonk, P. T.....Brooklyn, N. Y.
O'Neil, C. H........Brooklyn, N. Y.
O'Neil, F. W.......New York, N. Y.
O'Neil, R. D......Birmingham, Ala.
O'Neill, G. W...Calgary, Alta., Can.
O'Neill, J. L.......Providence, R. I.
O'Neill, T.......Toronto, Ont., Can.
Onsrud R. F............Chicago, Ill.
Oonk, W. J...........St. Louis, Mo.
Opdyke, W. J.........Rahway, N. J.
Ophuls, F..........New York, N. Y.
Opie, E. J............Dudley, Eng.
Oppenheimer, E. A.............
Cedar Rapids, Iowa
Oppenheimer, P. H.............
Upper Montclair, N. J.
Orazio, F. D..........Detroit, Mich.
Orbeck, E. M........Norristown, Pa.
Orcutt, A. H........Lapworth, Eng.
Orcutt, H. F. L....Birmingham, Eng.
Ordway, E. P....Battle Creek, Mich.
O'Regan, W. F.....Dorchester, Mass.
O'Reilly, A. J........St. Louis, Mo.
Oren, S. E...Long Island City, N. Y.
Orenstein, H..Prague, Czechoslovakia
Orghidan, C.....Bucharest, Rumania
Orloff, S...........Philadelphia, Pa.
Orman, H. K......New York, N. Y.
Ormond, A. M........Savannah, Ga.
Ormondroyd, J.....Philadelphia, Pa.
Orno, K. E...........Buffalo, N. Y.
O'Rourke, P. E. T......Denver, Colo.
Orr, A. M..........New York, N. Y.
Orr, C. L............Newgulf, Tex.
Orr, C. H..........Batavia, N. E. I.
Orr, F. B..............Chicago, Ill.
Orr, H. S.................Gary, Ind.
Orr, J......Johannesburg, S. Africa
Orr, J. L..........Philadelphia, Pa.
Orrell, J. E.............Tulsa, Okla.
Orrok, G. A........New York, N. Y.
Orrok, G. A., Jr.......Boston, Mass.
Ort, F. C..........New York, N. Y.
Ortla, F. L............Milton, Mass.
Ortman, H.........Des Moines, Iowa
Ortner, L..........New York, N. Y.
Orton, A. W............Utica, N. Y.
Osborn, E. P.....Washington, D. C.
Osborn, J. R............DuBois, Pa.
Osborne, L. A......Stockbridge, Mass.
Osbourne, W. A.....Galt, Ont., Can.
Osgood, F. G.........Meadville, Pa.
Osgood, J. L...........Buffalo, N. Y.
O'Shea, D. W....Montreal, Que., Can.
O'Shea, J..........New York, N. Y.
Osinski, L. F......Wilmington, Del.
Osipovich, A. A.......Portland, Ore.
Ossman, E. H....Santa Monica, Calif.
Oster, E. A.........Cincinnati, Ohio
Osterman, P. C......Elizabeth, N. J.
Ostermann, R. M........Chicago, Ill.
Ostlund, B. T. O...E. Pittsburgh, Pa.
Ostrand, J. A., Jr.....Seattle, Wash.
Oswald, E. P.........Allentown, Pa.
Oswald, J. C.......New York, N. Y.
Oswald, W. B....Santa Monica, Calif.
Othus, J. C..........Corvallis, Ore.
Ott. L. A..............Angola, Ind.
Otte, A. F............Detroit, Mich.
Otte, K. H. P..........Chicago, Ill.
Otterbein, M. E.......Newark, N. J.
Otterson, J. E......New York, N. Y.
Otto, H. McC.....Schenectady, N. Y.
Outzen, A. N.........Detroit, Mich.
Overton, R. M.......Pittsburgh, Pa.
Overton, W. J......New York, N. Y.
Overwater, J.........Newark, N. J.
Ovesen, H.............Poland, Ohio
Ovestrud, M....S. Minneapolis, Minn.
Owen, C. D...........Passaic, N. J.
Owen, E. V...........Boston, Mass.
Owens, C. T.........Norristown, Pa.
Owens, E. R...........Ensley, Ala.
Owens, J. W...........Beloit, Wis.
Oxford, C. J..........Detroit, Mich.
Oyen, E. O........Youngstown, Ohio
Ozley, G. R...........Tarrant, Ala.

P

Paca, J. P.............Canton, Ohio
Pace, E. W.....Salt Lake City, Utah
Packard, H. N........Ossining, N. Y.
Packard, R. A...........Lee, Mass.
Paddock, C. B...San Francisco, Calif.
Paddock, R. G.....Fayetteville, Ark.
Padgett, J. C..........Tulsa, Okla.
Padgett, W. C.....River Edge, N. J.
Paech, E. G......Los Angeles, Calif.
Paffen, P. J........New York, N. Y.
Page, C. B.............Chicago, Ill.
Page, H. W.........Sterlington, La.
Page, S. C.........Rochester, N. Y.
Page, S. H.........Los Gatos, Calif.
Pahmeyer, F. O.......St. Louis. Mo.
Paige, J. F...........Quincy, Mass.
Pailin, G..........Manchester, Eng.
Paine, A. P.........Brooklyn, N. Y.
Paine, W. S........Hartford, Conn.
Palafox, R. M......New York, N. Y.
Palatine, R. L......Waterbury, Conn.
Palatsky, G........New York, N. Y.
Palm, R.............Fairfield, Ala.
Palmer, A.........Worcester, Mass.
Palmer, D. M.........Toledo, Ohio
Palmer, E..........Ridley Park, Pa.
Palmer, E. S.......Montrose, Calif.
Palmer, E. W.......Kingsport, Tenn.
Palmer, H. O.........Geneva, N. Y.
Palmer, J. H.........Baltimore, Md.
Palmer, L. R.......New York, N. Y.
Palmer, R. M......New York, N. Y.
Palmer, S. B., Jr......Scranton, Pa.
Palmer, V. M......Rochester, N. Y.
Palmer, W. C.........Detroit, Mich.
Palmer, W. J. D.......Sydney, Aust.
Palsgrove, G. K.........Troy, N. Y.
Pamphilon, G. M.....Berkeley, Calif.
Panak, L. P.......New York, N. Y.
Pancoast, J. D........Buffalo, N. Y.
Pangborn, R. G.............
Jackson Heights, L. I., N. Y.
Panish, E. J.......Bridgeport, Conn.
Panitz, K. A......Binghamton, N. Y.
Pansegrau, C........E. Orange, N. J.
Panton, W. R.........Detroit, Mich.
Panuska, F. C...Corona, L. I., N. Y.
Panza, J. E........Somerville, Mass.
Pape, E...........Waterbury, Conn.
Pape, P. F......New Rochelle, N. Y.
Papemfuss, C. A.....New York, N. Y.
Pappas, C. E.................
College Point, L. I., N. Y.
Paque, E. J.........Cincinnati, Ohio
Parce, J. Y., Jr........Denver, Colo.
Paret, H. W., Jr...Philadelphia, Pa.
Paris, P. G..........Bethlehem, Pa.
Parish, W. F.......New York, N. Y.
Park, C. F.........Cambridge, Mass.
Park, C. P........Manchester, N. H.
Park, F. A.........New York, N. Y.
Park, R. B..........Hartford, Conn.
Parke, P...............Chicago, Ill.
Parken, E. A...........Butte, Mont.
Parker, A. La R.....Cleveland, Ohio
Parker, A. R.......Cincinnati, Ohio
Parker, A. W.......Harrison, N. J.
Parker, C. E...........Newark, N. J.
Parker, C. M........New York, N. Y.
Parker, E. B........Pullman, Wash.
Parker, E. E.....Schenectady, N. Y.
Parker, F. A......Auburndale, Mass.

Parker, Geo. Adelbert..........
Salt Lake City, Utah
Parker, Geo. Alfred............
Port Richmond, S. I., N. Y.
Parker, G. C......Woonsocket, R. I.
Parker, H. F........Pittsburgh, Pa.
Parker, Harry M...............
Laurelton, L. I., N. Y.
Parker, Henry M.....Syracuse, N. Y.
Parker, H. S........New York, N. Y.
Parker, J..........New York, N. Y.
Parker, John Castlereagh.......
New York, N. Y.
Parker, John Clinton..........
Philadelphia, Pa.
Parker, Jas. W........Detroit, Mich.
Parker, John W., Jr.....Atlanta, Ga.
Parker, K............Buffalo, N. Y.
Parker, L. M.........Barberton, Ohio
Parker, McR.........Cleveland, Ohio
Parker, R. L...........Manila, P. I.
Parker, R. S........Cincinnati, Ohio
Parker, S. S...........Casper, Wyo.
Parkerson, W.......New Orleans, La.
Parkin, J. H......Ottawa, Ont., Can.
Parkinson, Roger W............
New Rochelle, N. Y.
Parkinson, Russell W..Jackson, Mich.
Parks, A. M...........Chicago, Ill.
Parks, G. U.........Fall River, Mass.
Parks, M. B.....Hudson Falls, N. Y.
Parlett, R. C.......New York, N. Y.
Parlini, A. C.......New York, N. Y.
Parmakian, J..........Denver, Colo.
Parmeley, J. C........St. Louis, Mo.
Parmenter, L. E..........Reno, Nev.
Parmesan, D. J........Houston, Tex.
Parmley, S. M.......Pittsburgh, Pa.
Parr, H. L.........New York, N. Y.
Parr, J. B........Lance Creek, Wyo.
Parrello, F.........Hoboken, N. J.
Parrish, F..........New York, N. Y.
Parrish, J. S.........Richmond, Va.
Parrock, H. P...San Francisco, Calif.
Parry, E. J.............Rome, N. Y.
Parry, E. M.........Hartford, Conn.
Parry, H. L.........New York, N. Y.
Parsell, R. L.....New Haven, Conn.
Parsons, C. W.......New York, N. Y.
Parsons, F. A.......Milwaukee, Wis.
Parsons, G. K.......New York, N. Y.
Parsons, H. C...Salt Lake City, Utah
Parsons, H. N..........Chicago, Ill.
Parsons, L. D., Jr....Glen Ellyn, Ill.
Parsons, L. J.......New York, N. Y.
Parsons, W. M.........Chicago, Ill.
Parthesius, H. J...............
Manhasset, L. I., N. Y.
Partington, J......New York, N. Y.
Partridge, H. E..Edinburgh, Scotland
Pascale, J. A.......New Haven, Conn.
Paschall, A. L.............Troy, Ohio
Pasini, A. C..........Detroit, Mich.
Pasman, J. S...........Newark, N. J.
Passano, E. B.........Baltimore, Md.
Passano, W. M.......Baltimore, Md.
Pastoriza, H. G.....New York, N. Y.
Patch, E. S............Dayton, Ohio
Patch, F. R............Rutland, Vt.
Patel, C. M...........Baroda, India
Paterson, A. B......New Orleans, La.
Paterson, J. V........Seattle, Wash.
Paterson, L. B.......New York, N. Y.
Pathak, M. L.........Dichkot, India
Patinga, C. B.....Los Angeles, Calif.
Patitz, G. J..........New York, N. Y.
Patitz, G. N.........Peekskill, N. Y.
Patitz, J. F. M......Milwaukee, Wis.
Paton, W. R......Los Angeles, Calif.
Patscheider, W. A......Boston, Mass.
Patt, I. F.............Detroit, Mich.
Patten, E. L. O.........Chicago, Ill.
Patterson, A. W.....New York, N. Y.
Patterson, B. S.....New York, N. Y.
Patterson, C. B....Hattiesburg, Miss.
Patterson, D. W.........Chicago, Ill.
Patterson, F.....New Britain, Conn.
Patterson, L. S.....New York, N. Y.
Patterson, P. C.......Dravosburg, Pa.
Patterson, W. L....Maryville, Tenn.
Patterson, W. S....New York, N. Y.
Patthey, A. R.Bay Shore, L. I., N. Y.
Pattison, F........Manhattan, Kan.
Pattison, R. C........Brewster, Ohio
Paugh, C. T...........Fulton, N. Y.
Paugh, G. R.......New York, N. Y.
Paukner, F. J.......Brooklyn, N. Y.
Paul, C. Van S........Malden, Mass.
Paul, G. W........New York, N. Y.
Paul, J. S..............Chicago, Ill.
Paul, J. W....Newark Valley, N. Y.
Paul, R. C.............Auburn, N. Y.
Pauling, F. W.........Springfield, Vt.
Paull, W. R...........Visalia, Calif.
Paulsen, A. G.......New York, N. Y.
Paulsen, J.........Cambridge, Mass.
Paulson, P. A........Appleton, Wis.
Paulson, P. E.................
Vancouver, B. C., Can.
Pauly, W. C........Barberton, Ohio
Pausin, H. R..........Newark, N. J.
Pavey, W. J...........Chicago, Ill.
Paxton, C. H.....Los Angeles, Calif.
Payne, E. C........New York, N. Y.
Payne, F. E............Chicago, Ill.
Payne, F. H..............Erie, Pa.
Payne, S. F........Naugatuck, Conn.
Peabody, E. C....Breckenridge, Colo.
Peabody, E. H.....New York, N. Y.
Peace, C. S.........New York, N. Y.
Pearce, B. L.......Indianapolis, Ind.
Pearce, E. S.......Indianapolis, Ind.
Pearce, L. F.........New York, N. Y.
Pearce, R. T..........Rahway, N. J.
Pearce, R. W.......Providence, R. I.
Pearce, S............Ventura, Calif.
Pearl, J. W............Chicago, Ill.
Pearman, S. E......New York, N. Y.
Pearsall, H. S.........Avenal, Calif.
Pearson, A. K., Jr...Charlotte, N. C.
Pearson, F. A........Paterson, N. J.
Pearson, H. R..........Dallas, Tex.
Pearson, J. E.........Cleveland, Ohio
Pearson, L. J.......Philadelphia, Pa.
Pearson, O. N.......New York, N. Y.
Pearson, R..........Harrisburg, Pa.
Pearson, W. A.......Harrisburg, Pa.
Pease, F. G.........Pasadena, Calif.
Peasé, H. W..........Lansdowne, Pa.
Pease, R. M...........St. Louis, Mo.
Peaslee, D. N.........Boston, Mass.
Peaslee, W..........Cincinnati, Ohio
Peaslee, W. D. A...Indianapolis, Ind.
Peavey, J. M........Shelbyville, Tenn.
Peck, C. B.........New York, N. Y.
Peck, C. E.........E. Pittsburgh, Pa.
Peck, E. C..........Cleveland, Ohio
Peck, R. LeB.....Los Angeles, Calif.
Pecker, J. S........Philadelphia, Pa.
Peebles, T. A.........Pittsburgh, Pa.
Peets, W. J..........Elizabeth, N. J.
Pegg, A. O......Los Angeles, Calif.
Pegg, E. H. R......E. Pittsburgh, Pa.
Peglow, W.........Springfield, Mass.
Pegram, G. B.......New York, N. Y.
Pegram, W. B.....Prospect Park, Pa.
Pei, C. P...............Chicago, Ill.
Peiler, K. E.........Hartford, Conn.
Peirce, C. J., Jr....New Orleans, La.
Peirce, W. H.......Cockeysville, Md.
Peix, C. H..........Worcester, Mass.
Peller, L.................Chicago, Ill.
Pelletier, D. S.......Cincinnati, Ohio
Pelletier, E. J..........Salem, Mass.
Pellett, W. H....Windsor, Ont., Can.
Pelton, E. W.....New Britain, Conn.
Peltz, G. M...........Portland, Ore.
Pemberton, C..........Oakland, Ill.
Pender, W. R.......New Orleans, La.
Pendleton, M. S....New York, N. Y.
Pendray, E. E.......Champaign, Ill.
Penn, M..............Newark, N. J.
Pennebaker, R. H.........Tulsa, Okla.
Pennell, D. F.........Brooklyn, N. Y.
Penney, H. D......New York, N. Y.
Penney, L. W.................
Newton Highlands, Mass.
Penniman, A. L., Jr...Baltimore, Md.
Penning, C. J. H......Mandva, India
Penrose, C.........Philadelphia, Pa.
Penruddocke, J. H........Bath, Eng.
Penvenne, J............Lenox, Mass.
Peper, J. H.........New York, N. Y.
Pepoon, P. W.........Hampton, Va.
Pepper, E...Long Island City, N. Y.
Pepperman, C. W...Naugatuck, Conn.
Peppler, W. C........Detroit, Mich.
Peragallo, J.........Rochester, N. Y.
Percy, J. P....Central Aguirre, P. R.
Peres, A. P.......New York, N. Y.
Perez, M.............Panama, C. A.
Perkins, A. T..........St. Louis, Mo.
Perkins, D. L........Detroit, Mich.
Perkins, H. C..........Ithaca, N. Y.
Perkins, P. M.........Detroit, Mich.
Perkins, R. L., Jr......Eastport, Me.
Perkins, S. E.........Antioch, Calif.
Perkins, W. E.........Passaic, N. J.
Perkins, W. F........Baltimore, Md.
Perley, J. D.........Hartford, Conn.
Perotto, R..........Brooklyn, N. Y.
Perret, A. E........New York, N. Y.
Perrin, D. H.......Waterbury, Conn.
Perrone, P..............Rome, Italy
Perrone, S.............Austin, Tex.
Perrott, W.........New York, N. Y.
Perry, D. B...........Ithaca, N. Y.
Perry, E. H............Chicago, Ill.
Perry, H. M.....Los Angeles, Calif.
Perry, H. S.........New York, N. Y.
Perry, L. H........Springfield, Ohio
Perry, M. F.........Kingston, R. I.
Perry, N............New York, N. Y.
Perry, R. C........Waterbury, Conn.
Perry, R. H.......Torrington, Conn.
Perry, R. L............Davis, Calif.
Perry, S. S.........Winthrop, Mass.
Perry, T.............Portland, Ore.
Perry, T. D........Philadelphia, Pa.
Persiani, C. C.....Plantsville, Conn.
Perso, E. E...........Portland, Ore.
Person, E. R......Leominster, Mass.
Person, H. A......New York, N. Y.
Person, H. S........New York, N. Y.
Persson, C. G........Birdsboro, Pa.
Peskin, L. C.......Worcester, Mass.
Peter, A. G.........Milwaukee, Wis.
Peter, B. H..New Dorp, S. I., N. Y.
Peter, W. J.........Brooklyn, N. Y.
Peterman, G. W..Binghamton, N. Y.
Peters, A. H........New York, N. Y.
Peters, C........Hamburg, Germany
Peters, E..........Brooklyn, N. Y.
Peters, F. C..........Palmerton, Pa.
Peters, H. C........New York, N. Y.
Peters, H. E..........Seattle, Wash.
Peters, W. H......State College, Pa.
Petersen, A. V.........Newark, N. J.
Petersen, C. E......New York, N. Y.
Petersen, J. H..Glendale, L. I., N. Y.
Petersen, P. J....Holbaek, Denmark
Petersen, S.............St. Louis, Mo.
Peterson, A..........Trenton, N. J.
Peterson, A. I......New York, N. Y.
Peterson, A. J......New York, N. Y.
Peterson, B. A........Rockford, Ill.
Peterson, E. T........Birdsboro, Pa.
Peterson, E. W....Kansas City, Mo.
Peterson, F. P., Jr............
Corpus Christi, Tex.
Peterson, G. E.......Brooklyn, N. Y.
Peterson, H., Jr.....Brooklyn, N. Y.
Peterson, J. D........Boston, Mass.
Peterson, J. G......Hartford, Conn.
Peterson, J. H.....Philadelphia, Pa.
Peterson, M. K..........Chanute, Kan.
Peterson, O. F..Flushing, L. I., N. Y.
Peterson, P. A......Plainfield, N. J.
Peterson, R. E....E. Pittsburgh, Pa.
Peterson, S. G..........Norfolk, Va.
Peterson, T. E.....W. Newton, Mass.
Peterson, V. A......Kansas City, Mo.
Peterson, V. H....Washington, D. C.
Petherick, R. L.......Harper, Wash.
Petitjean, C. P........Paris, France
Petrescu, O. S....Old Hickory, Tenn.
Petri, W. J.........Milwaukee, Wis.
Petrie, G. R.........Cadillac, Mich.
Petroe, G. A....Niagara Falls, N. Y.
Petroff, P. A......New York, N. Y.
Petroman, O. M.......Westerly, R. I.
Pettengill, G. D......Warsaw, N. Y.
Pettibone, C. E..........Boston, Mass.
Pettingill, F. M.......Laurel, Miss.
Pettinos, G. F..........Merion, Pa.
Pettit, A. R.........Philadelphia, Pa.
Petura, F. E......Schenectady, N. Y.
Pew, J. N., Jr......Philadelphia, Pa.
Peyinghaus, R......Plant City, Fla.
Peyser, J........Mt. Vernon, N. Y.
Pfaff, G. C...........Baltimore, Md.
Pfanku, H. D........Cleveland, Ohio
Pfautsch, R. V.........Chicago, Ill.
Pfefferle, F. H......Cincinnati, Ohio
Pfeiffer, C. G......Philadelphia, Pa.
Pfeiffer, I. F...........Altoona, Pa.
Pfeil, W. G...........Passaic, N. J.
Pfisterer, G. E........Chicago, Ill.
Pflager, H. M......Granite City, Ill.
Phalen, J. J........Brooklyn, N. Y.
Pharo, E. W., Jr....Swarthmore, Pa.
Phelan, John J....Washington, D. C.
Phelan, John Joseph.New York, N. Y.
Phelan, P. A.......Wilmington, Del.
Phelan, T. H......New York, N. Y.
Phelps, A. K........Cleveland, Ohio
Phelps, A. S...........Buffalo, N. Y.
Phelps, C. C......New York, N. Y.
Phelps, C. W...........Storrs, Conn.
Phelps, F. A...........Newark, N. J.
Phelps, K. G.........Detroit, Mich.
Philbrick, H. S........Evanston, Ill.
Phillips, E. L.......New York, N. Y.
Phillips, E. M.......W. Lynn, Mass.
Phillips, G. W. M....New York, N. Y.
Phillips, H. P..San Francisco, Calif.
Phillips, H. S......Providence, R. I.
Phillips, John C....Philadelphia, Pa.
Phillips, John Chester..........
Washington, D. C.
Phillips, L. A......Brooklyn, N. Y.
Phillips, M. C........Corvallis, Ore.
Phillips, R. L........Sterlington, La.
Phillips, V. B........Cleveland, Ohio
Phillips, Wm. Henry....Chicago, Ill.
Phillips, Wm. Henry John.....
Lynn, Mass.
Phillips, Wm. Hopestill.........
Pittsburgh, Pa.
Philo, F. G.......Long Beach, Calif.
Phinney, R. E.........Chicago, Ill
Phipps, A. J..........Canton, Ohio
Phyl, J...........New York, N. Y.
Piacitelli, J. A.....New York, N. Y.
Piazzoli, L. P., Jr..Connellsville, Pa.
Picado, R. M.................
San Jose, Costa Rica, C. A.
Picco, P. J..........St. Louis, Mo.
Pick, W. J.Valley Stream, L. I., N. Y.
Pickel, H. A.........Allentown, Pa.
Pickett, L..........Irvington, N. J.
Pickle, D. V............Austin, Tex.
Picucci, J. A......New York, N. Y.
Piekenbrock, R. A..New York, N. Y.
Pierce, A. C........E. Orange, N. J.
Pierce, A. J........Norwood, Mass.
Pierce, C..............Harvey, Ill.
Pierce, C. J............Norfolk, Va.
Pierce, E. R..........Detroit, Mich.
Pierce, F. E........New York, N. Y.
Pierce, H. R...........Ashland, Ky.
Pierce, J. D............Chicago, Ill.
Pierce, J. E...........Midland, Mich.
Pierce, J. V........Knoxville, Tenn.
Pierce, P. E., Jr.....Cleveland, Ohio
Pierce, R. C.......New York, N. Y.
Pierle, H. C........Cincinnati, Ohio
Pierson, J. W.........Chicago, Ill.
Piesen, R...........Brooklyn, N. Y.
Pieters, I. S...........Chicago, Ill.
Pigage, L. C.......Rochester, N. Y.
Pigott, R. J. S......Pittsburgh, Pa.
Pihlman, A. A......New York, N. Y.
Pike, J. G., Jr.......Goshen, N. H.
Pike, K. W............Akron, Ohio
Pike, R...........Welch, W. Va.
Pilcher, J. A..........Roanoke, Va.
Pilcher, W. S.......Gibbstown, N. J.
Pilgrim, H. J........Bellewood, Ill.
Pinckney, H. W......Ft. Smith, Ark.
Pindras, R.............Chicago, Ill.
Pines, C. A........Philadelphia, Pa.
Pinkerton, A........Pittsburgh, Pa.
Pinkerton, D. W........Eustis, Fla.
Pinkham, B. N....Deer River, Minn.
Pinkney, D. H.......Pittsburgh, Pa.
Pinney, C. G.......Philadelphia, Pa.
Pinney, E. F..Long Island City, N. Y.
Pinsan, P. E......Union City, N. J.
Piperoux, R. P.......Newark, N. J.
Pirnie, J. A........New York, N. Y.
Piskur, S....Conchas Dam, New Mex.
Pitcairn, H. F....Willow Grove, Pa.
Pitkin, E. S. B........Albany, N. Y.
Pitts, H. H....Chicago Heights, Ill.
Piwinski, E. J..........Chicago, Ill.
Place, C. A........New York, N. Y.
Place, C. R........New York, N. Y.
Placé, L. V., Jr....Philadelphia, Pa.
Place, O...............Aurora, Ill.
Plagwit, E..........Pittsburgh, Pa.
Planche, E...........Detroit, Mich.
Plapp, E. B............El Paso, Tex.
Plass, C. W........Philadelphia, Pa.
Plass, R. B....San Francisco, Calif.
Plass, R. H..Upper Montclair, N. J.
Plasse, H..........New York, N. Y.
Platou, L. S.......Waterbury, Conn.
Platt, J...........New York, N. Y.
Pletta, W. H....Schenectady, N. Y.
Pleukharp, C. W..Los Angeles, Calif.
Pliner, I. D....Leningrad, U. S. S. R.
Ploehn, J. H........Davenport, Iowa
Plonsker, M. J.........Chicago, Ill.
Plovanich, J. P..Charleston, W. Va.
Plume, W. F......Philadelphia, Pa.
Plummer, W. S.......Swissvale, Pa.
Podnossoff, J.................
Buenos Aires, Argentina, S. A.
Poehlmann, K. F.San Francisco, Calif.
Pogue, J. E........New York, N. Y.
Pohle, H. A...... Providence, R. I.
Pohlke, P. A........Philadelphia, Pa.
Polakov, N. N......New York, N. Y.
Pole, L. A........Lewisburg, W. Va.
Polglaze, R. A....Birmingham, Ala.
Poliakoff, R.........New York, N. Y.
Polich, V. L.........Roundup, Mont.
Polk, G. C...........Detroit, Mich.
Polko, P. P.............Lyons, Ill.
Pollard, E. V.........W. Lynn, Mass.
Pollard, R. S.......New York, N. Y.
Pollard, T. A..........Midland, Tex.
Polleys, H. R......New Haven, Conn.
Pollock, H. L......Fall River, Mass.
Pollock, W. M.........Blawnox, Pa.
Polomik, E. E.....Sunnyvale, Calif.
Polson, J. A............Urbana, Ill.
Pomerol, L.........Barcelona, Spain
Pomeroy, C. R........Toledo, Ohio
Pomeroy, G. M......Worcester, Mass.
Pomeroy, T. M., Jr..Philadelphia, Pa.
Poock, A. F...........Dayton, Ohio
Pook, C. H. O..Hamilton, Ont., Can.
Pool, C. B.............Boston, Mass.
Pool, R. Y............Miami, Fla.
Poole, E. J............Reading, Pa.
Poole, E. M............Easton, Pa.

Poore, A. C. R....Chillicothe, Ohio
Poorman, G. E........Buffalo, N. Y.
Pope, C. J...........Newark, N. J.
Pope, H. L.......Rochester, N. Y.
Pope, J............New York, N. Y.
Pope, S. A...........Chicago, Ill.
Popkin, M. E......New York, N. Y.
Popov, N. G........Barberton, Ohio
Popyk, W. W........Detroit, Mich.
Porter, A. J.........W. Linn, Ore.
Porter, D. B.......New York, N. Y.
Porter, F. P.......Kellogg, Idaho
Porter, H. H.......New York, N. Y.
Porter, H. P............Tulsa, Okla.
Porter, H. W.........Newark, N. J.
Porter, J. F........Kansas City, Mo.
Porter, L. J.......Hartford, Conn.
Porter, R. C..........Lexington, Ky.
Porter, R. E., Jr..Bowling Green, Ky.
Porter, R. H........Palmerton, Pa.
Posey, C. J.........Iowa City, Iowa
Posey, J............Baltimore, Md.
Posgate, J. S...........Texon, Tex.
Pospisil, L. J.........Spokane, Wash.
Pospisil, P. J..........Pender, Neb.
Possel, A. M......Washington, D. C.
Posselt, E........New York, N. Y.
Post, R. C........New York, N. Y.
Postel, K. I..........Detroit, Mich.
Potbury, A. H......Berkeley, Calif.
Pote, K. E..........Pittsburgh, Pa.
Potopinsky, M..N. Roslyn, L. I., N. Y.
Potter, A. A......W. Lafayette, Ind.
Potter, A. W........Brooklyn, N. Y.
Potter, E. M........New York, N. Y.
Potter, G. L........New York, N. Y.
Potter, H. LeR...New Britain, Conn.
Potter, J. D.......New York, N. Y.
Potter, J. H......Charleston, W. Va.
Potter, P. J.......Philadelphia, Pa.
Potter, W. H...........Chicago, Ill.
Potts, V. M..........Detroit, Mich.
Potts, W. K....San Francisco, Calif.
Pouch, L. O........New York, N. Y.
Poultney, J. L.....Bryn Mawr, Pa.
Pound, J. H...........Houston, Tex.
Powell, C. E..........Pittsburgh, Pa.
Powell, E. B..........Boston, Mass.
Powell, I. E........Rochester, N. Y.
Powell, J. A..........Reading, Pa.
Powell, J. L.......Philadelphia, Pa.
Powell, K. A......Minneapolis, Minn.
Powell, M. A........Pittsburgh, Pa.
Powell, O. I..........Newark, N. J.
Powell, P. R........Baltimore, Md.
Powell, W., Jr......Drexel Hill, Pa.
Powell, W. T...........Trona, Calif.
Power, J. A..........Houston, Tex.
Powers, J. H.........Hartford, Conn.
Powers, M. E..........Chicago, Ill.
Powl, W. R........Beaver Falls, Pa.
Pradl, G........Montreal, Que., Can.
Praetz, E. F........Lawrence, Mass.
Prageman, I. H..........Orono, Me.
Pragst, E........Schenectady, N. Y.
Prahl, F. A., Jr....New York, N. Y.
Prandoni, J. F.......Hoboken, N. J.
Praner, J. A...........Newark, N. J.
Prange, C. H........New York, N. Y.
Prass, H...........Brooklyn, N. Y.
Pratt, A. G.........New York, N. Y.
Pratt, C. A............Chicago, Ill.
Pratt, F. E...Avondale Estates, Ga.
Pratt, H. A........New York, N. Y.
Pratt, H. C........Rochester, N. Y.
Pratt, J. H............Chicago, Ill.
Pratt, M. S.......N. Plymouth, Mass.
Pratt, T. G........Wilmington, Del.
Pray, C. F.........Brooklyn, N. Y.
Pray, L. C....New Brunswick, N. J.
Preble, N. H..........Detroit, Mich.
Prendergast, J. F........Monroe, La.
Prendergast, W. A....St. Charles, Mo.
Prentice, D. B.....Terre Haute, Ind.
Prentice, H. M.......Massillon, Ohio
Prentice, J...........Bayonne, N. J.
Presbrey, O. F...........Newark, N. J.
Presby, L. Q.........Melrose, Mass.
Prescott, A. T.......New York, N. Y.
Prescott, C. S....Menominee, Mich.
Prescott, F. K.........Fresno, Calif.
Prescott, P. R.......Worcester, Mass.
Presdee, J. J.......New York, N. Y.
Pressy, R. W.......Philadelphia, Pa.
Preston, F. W......New Haven, Conn.
Preston, H. E.......Philadelphia, Pa.
Preston, W. B.........Newgulf, Tex.
Pretot, A. V........New York, N. Y.
Preudhomme, P. J...................
E. Windsor, Ont., Can.
Prianishnikoff, V. D..Cleveland, Ohio
Price, A. M...............Elgin, Ill.
Price, F. C....Chicago Heights, Ill.
Price, F. U...........Detroit, Mich.
Price, G. L......Babylon, L. I., N. Y.
Price, H...........New York, N. Y.
Price, H. M......Washington, D. C.
Price, H. W............Borger, Tex.
Price, J............New York, N. Y.
Price, J. W..........Coraopolis, Pa.
Price, L........Montour Falls, N. Y.
Price, L. C........Fayetteville, Ark.
Price, M..........W. Lafayette, Ind.
Price, M. L........Worcester, Mass.
Price, Manuel M......Sallisaw, Okla.
Price, Morton Moore.Philadelphia, Pa.
Price, N. I...........Sydney, Aust.
Price, S. L.........Brookline, Mass.
Price, T..........Glen Ridge, N. J.
Price, W. D........Knoxville, Tenn.
Prichard, W. J.......Audubon, N. J.
Priedeman, G. W..Minneapolis, Minn.
Primrose, J........New York, N. Y.
Prince, D.....Upper Montclair, N. J.
Prince, J. S........New York, N. Y.
Prince, R. J..........Allentown, Pa.
Prindle, E. J.......New York, N. Y.
Prins, A. W......New York, N. Y.
Prior, J. A........Philadelphia, Pa.
Prior, J. E...........Newark, N. J.
Pritchard, J. F.....Kansas City, Mo.
Pritchard, R. H.......Ossining, N. Y.
Probst, J....Farmingdale, L. I., N. Y.
Probst, J. J. R....Rutherford, N. J.
Procter, S. W...................
Midland Junction, Aust.
Proctor, G. N.........Kearny, N. J.
Proctor, R.............Proctor, Vt.
Proctor, W. E.......Baltimore, Md.
Proffitt, R. P...........Chicago, Ill.
Prohaska, R. J..........Omaha, Neb.
Propper, E. M....Philadelphia, Pa.
Pross, W. C.......Bainbridge, N. Y.
Prossen, P. J......San Antonio, Tex.
Prosser, J. G........Pasadena, Calif.
Prosser, R. D......New York, N. Y.
Prouty, F. H...........Denver, Colo.
Provine, C. R......Wolfe City, Tex.
Prozan, M...........Brooklyn, N. Y.
Prucha, V. L.......Burlington, Iowa
Prudden, O. D........Rittman, Ohio
Pruitt, R. S..........Anderson, S. C.
Prussing, R. E..........Chicago, Ill.
Pryde, D. R......Swannanoa, N. C.
Pryor, F. L..........Paterson, N. J.
Puc, V.......Prague, Czechoslovakia
Puffer, K. L...........Houston, Tex.
Pugh, A. H........Cincinnati, Ohio
Pugh, G. A.........Youngstown, Ohio
Puig, I. F............Havana, Cuba
Puishes, A..Port Ivory, S. I., N. Y.
Pullen, R. R............Lead, S. D.
Puller, O. G...................
Port Washington, L. I., N. Y.
Punnett, F. D.......Rochester, N. Y.
Purcell, J..............Chicago, Ill.
Purcell, J. P......Los Angeles, Calif.
Purcell, T. E........Pittsburgh, Pa.
Purdie, D. J........New York, N. Y.
Purdy, D. F...........Oilfields, Calif.
Purdy, G. C...........Rockford, Ill.
Purdy, H. E...........Newark, N. J.
Purdy, H. T...................
San Jose, Costa Rica, C. A.
Purdy, J. L.........Columbus, Ohio
Purdy, R. B........New York, N. Y.
Purinton, A. J...Atlantic City, N. J.
Purinton, F. G.....Waterbury, Conn.
Pursel, H. R.......Philadelphia, Pa.
Pursell, W.........Ft. Devens, Mass.
Pusnikas, K. A..Maspeth, L. I., N. Y.
Putnam, A. D.......Worcester, Mass.
Putnam, J. L.......Brooklyn, N. Y.
Putnam, J. R......Waterbury, Conn.
Putnam, J. W., Jr.......Chicago, Ill.
Putnam, L. J........Brooklyn, N. Y.
Putnam, S. T...................
Forest Hills, L. I., N. Y.
Putryae, J. E......Berkeley, Calif.
Pyle, L. M..........Eddystone, Pa.
Pyster, J. N....Chañaral, Chile, S. A.
Pyzel, E...........Pittsburg, Calif.

Q

Quackenbush, C. F.Bellingham, Wash.
Quackenbush, E. S..New York, N. Y.
Quarles, F. W.......Baltimore, Md.
Quarnstrom, A..San Francisco, Calif.
Quarterman, E. A.Poughkeepsie, N. Y.
Quast, W. F.......Philadelphia, Pa.
Quayle, A.............Oil City, Pa.
Quayle, L. A.......Cleveland, Ohio
Queisser, H. W......Berlin, Germany
Quenelle, O. G.........Roanoke, Ala.
Quereau, J. F.......Philadelphia, Pa.
Quick, H. P........Westfield, N. J.
Quick, R. S....San Francisco, Calif.
Quick, R. T......Los Angeles, Calif.
Quier, K. E.........Brooklyn, N. Y.
Quigley, W. S.......New York, N. Y.
Quillin, G..............Akron, Ohio
Quinlan, P. J......Philadelphia, Pa.
Quinn, A. M........Philadelphia, Pa.
Quinn, J. B.......Jersey City, N. J.
Quinn, R. P.........Mansfield, Ohio
Quinn, W. H....Bayside, L. I., N. Y.
Quirk, C. H........New York, N. Y.
Quirke, E. D..........Kewanee, Ill.

R

Raabe, E. R.......New York, N. Y.
Rabbitt, J. A..........Tokyo, Japan
Rabe, F. W............Dallas, Tex.
Rabe, J. S........Philadelphia, Pa.
Raber, B. F........Berkeley, Calif.
Rabert, A. P..........Allentown, Pa
Rabl, H...........Philadelphia, Pa.
Rabuck, J. A..........Louisville, Ky.
Rach, J. L. W........Baltimore, Md.
Rachals, W........New York, N. Y.
Radden, C. O..........Boston, Mass.
Radecki, M. J....New Haven, Conn.
Rader, E. D.......New York, N. Y.
Radetich, F. E..San Francisco, Calif.
Radford, G. S....New Canaan, Conn.
Radom, G. L.......New York, N. Y.
Radvillas, C. K........Dayton, Ohio
Rae, J................Havana, Cuba
Raetsch, B. A......New York, N. Y.
Raetz, S. J.........New York, N. Y.
Rafter, P. T..........St. Louis, Mo.
Ragland, R. K........Creighton, Pa.
Ragland, W. M.........Chicago, Ill.
Rahm, F. D..........Houston, Tex.
Rahm, F. W..........Brooklyn, N. Y.
Rahm, H. E.............Passaic, N. J.
Rahm, L. F.........Princeton, N. J.
Rahm, R. C........Wyomissing, Pa.
Raif, A. S.......Address Unknown
Raisch, W..........New York, N. Y.
Raisig, C. L..........Pittsburgh, Pa.
Raisler, R. K......New York, N. Y.
Raitt, G. H..........Berkeley, Calif.
Raju, C. S. N....Jāmshedpur, India
Rall, C. O............Boston, Mass.
Ralston, A. E.....Southington, Conn.
Ralston, E. K.......Cleveland, Ohio
Ralton, F. A........Lawrence, Mass.
Ram, R. A., Sr........Ujjain, India
Ramage, E. C. Jr....New York, N. Y.
Ramage, R. W.......Rochester, N. Y.
Ramaswami, E. K....Bangalore, India
Rambolt, C. L..........Chicago, Ill.
Ramer, G. E.......Wilmington, Del.
Ramirez, A. E......San Juan, P. R.
Ramirez, E.........Mayaguez, P. R.
Ramm, H. F..........Bristol, Conn.
Ramos, L. C...........Ponce, P. R.
Ramsauer, E. C..Roslyn, L. I., N. Y.
Ramsay, E.........Birmingham, Ala.
Ramsay, W. A......Honolulu, T. H.
Ramsden, J. T.....Philadelphia, Pa.
Ramsey, C. H.......Glen Rock, N. J.
Ramsey, G.........New York, N. Y.
Ramsey, W. K......Worcester, Mass.
Randall, G. B.......Hamilton, Ohio
Randall, J. A.....Washington, D. C.
Randall, J. F.........Detroit, Mich.
Randall, N..........Cleveland, Ohio
Randolph, D. N......Pittsburgh, Pa.
Randolph, F. H.........Ithaca, N. Y.
Randolph, J. R.......Kingston, R. I.
Rang, E............Norwich, Conn.
Rank, H. L.......Minneapolis, Minn.
Ranken, H. B.........Newark, N. J.
Rankin, J. K......E. Pittsburgh, Pa.
Rankin, R. A....Montreal, Que., Can.
Rankin, W. J. A....Maplewood, N. J.
Ranney, L.......Petrolia, Ont., Can.
Ranno, D. B..........Salem, N. J.
Ransford, L. A......Barberton, Ohio
Ransohoff, N........Cincinnati, Ohio
Ransom, J. F.....Swampscott, Mass.
Ransom, L. H.....Beaver Falls, Pa.
Ransom, W. G.........Ottawa, Kan.
Ranstead, N. H.........Chicago, Ill.
Rantsch, E. J....Hollis, L. I., N. Y.
Rantz, C. F............Algiers, La.
Rao, B. L........Vizianagram, India
Rao, K. N..........Hindupur, India
Rao, M. K..........Bombay, India
Rapley, F. A.........London, Eng.
Rapp, A. G. J.........Chicago, Ill.
Rasmusen, J. E....Fort Worth, Texas
Rasmussen, Find....Brooklyn, N. Y.
Rasmussen, Frank......Chicago, Ill.
Rasmussen, H. V....Swarthmore, Pa.
Rasmussen, R. C....Philadelphia, Pa.
Rataiczak, T. F..........Troy, Ohio
Ratcliff, V. H..........Chicago, Ill.
Ratcliffe, F. R.........Sydney, Aust.
Rathbun, E.............Toledo, Ohio
Rathgeb, A..........Plainfield, N. J.
Rathjens, G. W..Salt Lake City, Utah
Rathman, G...........Newark, N. J.
Rathzburg, P. D......Boston, Mass.
Rau, O. M..........Philadelphia, Pa.
Raub, J. H........Waterbury, Conn.
Rauch, J. D...............Lima, Ohio
Rauch, L. K....E. Weymouth, Mass.
Rauch, R. T.........Barberton, Ohio
Raume, A. A...........Laramie, Wyo.
Raunick, E. J. M....Milwaukee, Wis.
Rausch, V. H..........Newark, N. J.
Rautenstrauch, W...New York, N. Y.
Raworth, A. S....Bearsden, Scotland
Rawson, A. J......Philadelphia, Pa.
Ray, A. A.........Los Angeles, Calif.
Ray, D. H........Los Angeles, Calif.
Ray, T.............Manistee, Mich.
Raymond, A. A.........Buffalo, N. Y.
Raymond, E. P.........Detroit, Mich.
Raymond, F. E....Cambridge, Mass.
Raymond, G....Oklahoma City, Okla.
Raymond, L. E.........Staunton, Va.
Raymond, R. P........Mansfield, Ohio
Raymond, W.............Easton, Pa.
Rea, J. A.............Buffalo, N. Y.
Rea, J. T...........Bethlehem, Pa.
Read, C. A.........Worcester, Mass.
Read, L. B............St. Louis, Mo.
Read, M. H.........Philadelphia, Pa
Reali, C. M..........Barberton, Ohio
Rearick, C. B......New York, N. Y.
Reaser, W. E............Easton, Pa.
Reaser, W. W..........Seattle, Wash.
Reast, W. M.........Chickasaw, Ala.
Reber, L. E............Tucson, Ariz.
Reburn, C. E..........Eddystone, Pa
Rech, H. F............Detroit, Mich.
Reckford, J. K.......Hoboken, N. J.
Recknagel, F. W..Poughkeepsie, N. Y.
Redden, C. A.........Waterville, Me.
Reddert, E. J......Maplewood, N. J.
Reddick, M. E..........Denver, Colo.
Redfield, C...........Newark, N. J.
Redfield, S. B........Catasaqua, Pa.
Redin, E. G............Chicago, Ill.
Redman, D. F..........Chicago, Ill.
Redmerski, E. S....New York, N. Y.
Redmond, J. H....Wilkinsburg, Pa.
Reece, R. P....Winston-Salem, N. C.
Reed, A. B............Boston, Mass.
Reed, A. C......Santa Monica, Calif.
Reed, C. T.........Worcester, Mass.
Reed, E. A..........Pittsburgh, Pa.
Reed, E. H.........Worcester, Mass
Reed, F. J...........Durham, N. C.
Reed, F. T.........New Orleans, La.
Reed, G. S............Detroit, Mich.
Reed, H. D..........New York, N. Y.
Reed, J. C.............Urbana, Ill.
Reed, J. R.............Napa, Calif.
Reed, K. W..........Cleveland, Ohio
Reed, M. J.........New York, N. Y.
Reed, M. S..................Erie, Pa.
Reed, R. J.......Los Angeles, Calif.
Reed, R. M........Birmingham, Ala.
Reed, T. E.........Lawrence, Mass.
Reed, V. A., Jr.....Pittsburgh, Pa.
Reed, W..............Buffalo, N. Y.
Reed, Wm. Albert..Schenectady, N. Y.
Reed, Wm. Anthony....Detroit, Mich.
Reed, W. E.........New York, N. Y.
Rees, J. R............Shaniko, Ore.
Rees, M. D..........Rushville, Ind.
Reese, E. W., Jr....Cincinnati, Ohio
Reese, L. V......Washington, D. C.
Reese, W. J.............Ottawa, Ill.
Reeve, K. A.........Somerville, N. J.
Reeves, C.............Trenton, N. J.
Reeves, E. H.........Hartford, Conn.
Reeves, W. H........St. Louis, Mo.
Regan, J. C....Windsor Locks, Conn.
Regan, J. D....San Francisco, Calif.
Reggel, W. G. A..Huntington, W. Va.
Reggiori, A...............Milan, Italy
Register, A. L.....St. Michaels, Md.
Rehfuss, W. C......Philadelphia, Pa.
Reich, H. L............Manila, P. I.
Reichard, H. G......Cleveland, Ohio
Reichard, P. C.........Bethlehem, Pa.
Reichel, C. R....San Francisco, Calif.
Reichelt, C. V.Westerleigh, S. I., N. Y.
Reichenbach, H.....Waynesboro, Pa.
Reichenbach, H. A.....Nazareth, Pa.
Reichert, W. G......Elizabeth, N. J.
Reid, A.............Worcester, Mass.
Reid, E. A..........Morrisville, Pa.
Reid, H............New York, N. Y.
Reid, H. P............Chicago, Ill.
Reid, J................Oil City, Pa.
Reid, J. W., Jr......Camden, N. J.
Reid, W...............Dallas, Tex.
Reidl, A. L.......Philadelphia, Pa.
Reighard, R. H.....Coldwater, Mich.
Reiley, R. C............Chicago, Ill.
Reilly, B. B.......Philadelphia, Pa.
Reilly, F. W......Chattanooga, Tenn.
Reilly, J. H.......New York, N. Y.
Reilly, T. J........Bloomfield, N. J.
Reimer, C. C........Hamilton, Ohio

Reimers, B. F........Paterson, N. J.
Reimuller, C. L........Chicago, Ill.
Reinecke, H. H....Youngstown, Ohio
Reinertson, J. H........Beloit, Wis.
Reinhardt, B. R.....Pittsfield, Mass.
Reinhold, W. R......Milwaukee, Wis.
Reinicker, N. G......Allentown, Pa.
Reiniger, E. M......Cincinnati, Ohio
Reinke, C. C......New Milford, N. J.
Reisman, F. W......New York, N. Y.
Reissig, A. R........Albany, N. Y.
Reist, H. G......Schenectady, N. Y.
Reiter, B. Z.........New York, N. Y.
Reitz, E. J......Niagara Falls, N. Y.
Reitzel, H. B..........Chicago, Ill.
Reker, C. H.........New York, N. Y.
Remanjon, A. deR..New Orleans, La.
Remelman, E......New York, N. Y.
Remeschatis, R. E....Brooklyn, N. Y.
Remmers, H. L. W..Philadelphia, Pa.
Renner, R. B........New York, N. Y.
Rennie, J. A........Brooklyn, N. Y.
Rennie, R..........New York, N. Y.
Reno, H. P.......Saylesville, R. I.
Renwick, E. B......New York, N. Y.
Reoch, A. G........New York, N. Y.
Repath, C. H....Los Angeles, Calif.
Repino, P...........Burnham, Pa.
Repko, J. S..................
Queens Village, L. I., N. Y.
Repscha, A. H......Philadelphia, Pa.
Resek, M..........Cleveland, Ohio
Reswick, M........New York, N. Y.
Retz, A. M..........Brooklyn, N. Y.
Reuling, W. E.....E. Lansing, Mich.
Reunert, T...Johannesburg, S. Africa
Reusch, V. M.......Brooklyn, N. Y.
Reuter, P. T..........Boston, Mass.
Revere, F. J.......Wauwautosa, Wis.
Rewalt, J. K.......New York, N. Y.
Reydon, H...Amsterdam, Netherlands
Reyling, G......Mineola, L. I., N. Y.
Reynell, C.....Flushing, L. I., N. Y.
Reynick, H. F......New Orleans, La.
Reynolds, B. A.........Altoona, Pa.
Reynolds, E. A....Somerville, N. J.
Reynolds, F. W..........Boston, Mass.
Reynolds, H. B....New York, N. Y.
Reynolds, R. L.....Mt. Vernon, Ohio
Reynolds, S. W......Westfield, N. J.
Reynolds, W. C....New York, N. Y.
Reynolds, W. E.....New York, N. Y.
Reznek, B........Washington, D. C.
Rhame, F. P.........Cincinnati, Ohio
Rhine, C. K........New York, N. Y.
Rhinehart, J. R.......Park Ridge, Ill.
Rhoades, J. F......Chillicothe, Ohio
Rhoads, G. E...........Altoona, Pa.
Rhoads, P. G.......Wilmington, Del.
Rhoads, R. L.....Washington, D. C.
Rhodes, F. A., Jr....Glendale, Calif.
Rhodes, F. H., Jr.....Seattle, Wash.
Rhodes, G. H.......New York, N. Y.
Rhodes, G. I........New York, N. Y.
Rhodes, K..........Syracuse, N. Y.
Riblett, G. H......Fairmont, W. Va.
Rice, A. H............Chicago, Ill.
Rice, A. L.............Chicago, Ill.
Rice, C. D..........Hartford, Conn.
Rice, C. H.........Philadelphia, Pa.
Rice, C. W...........Pittsburgh, Pa.
Rice, F. J.......Roselle Park, N. J.
Rice, G. L.........New York, N. Y.
Rice, H. C...........Buffalo, N. Y.
Rice, J. R...........Johnstown, Pa.
Rice, M. W..........Memphis, Tenn.
Rice, R. A............Chicago, Ill.
Rice, R. B............Raleigh, N. C.
Rice, W. E.........Pittsburgh, Pa.
Rich, G. R............Boston, Mass.
Richards, A. S.........Boston, Mass.
Richards, C. L.......Cincinnati, Ohio
Richards, C. R...Minneapolis, Minn.
Richards, E. H....Washington, D. C.
Richards, E. M......Cleveland, Ohio
Richards, G. B.......Oakland, Calif.
Richards, G. R.Long Island City, N. Y.
Richards, H. E...San Francisco, Calif.
Richards, H. F....Los Angeles, Calif.
Richards, Homer F....Boston, Mass.
Richards, K.....Poughkeepsie, N. Y.
Richards, L. T......Coffeyville, Kan.
Richards, W. A...Montreal, Que., Can.
Richards, W. E........Avenel, N. J.
Richardson, A. C....New York, N. Y.
Richardson, B. E............
Grand Rapids, Mich.
Richardson, C. G...Providence, R. I.
Richardson, C. H....Hartford, Conn.
Richardson, E. A......Bethlehem, Pa.
Richardson, E. B.......Boston, Mass.
Richardson, F. E......Massena, N. Y.
Richardson, G. P......Newark, N. J.
Richardson, H. C.....Syracuse, N. Y.
Richardson, L. A., Jr....Chicago, Ill.
Richardson, L. F..Los Angeles, Calif.
Richardson, M. B...Livingston, N. J.
Richardson, M. F........Berwyn, Pa.
Richardson, P. L....New York, N. Y.
Richardson, R. G...Philadelphia, Pa.
Richardson, T. B....Hartford, Conn.
Richhart, W. S.....Indianapolis, Ind.
Richmond, H. A.Niagara Falls, N. Y.
Richmond, J.......Brooklyn, N. Y.
Richmond, J. D.....Brooklyn, N. Y.
Richmond, J. L.....Springfield, Mass.
Richmond, O. J....Bridgeport, Conn.
Richmond, R. L.....New York, N. Y.
Richmond, W. O.....Cleveland, Ohio
Richter, E..........Cincinnati, Ohio
Richter, G. A.........Denver, Colo.
Richter, W. W......New York, N. Y.
Rick, C............Milwaukee, Wis.
Rickard, H. C.........Boston, Mass.
Rickcord, R. V...............
Jackson Heights, L. I., N. Y.
Ricketson, W. E.....New York, N. Y.
Ricketts, E. B.....New York, N. Y.
Ricketts, G. B. S....New Orleans, La.
Ricketts, R............Sulphur, La.
Ricketts, R. D.......Columbus, Ohio
Rickey, D..........Philadelphia, Pa.
Rickman, A. A......New York, N. Y.
Rickwood, R. L.....Arlington, Mass.
Riconda, L. J........Hamden, Conn.
Ridabock, J. H......Riverside, Conn.
Riddell, A. H......Philadelphia, Pa.
Riddell, J...........Detroit, Mich.
Riddell, J. T., Jr.......Evanston, Ill.
Riddiford, A. B., Jr....Rockford, Ill.
Riddle, Herbert S...N. Adams, Mass.
Riddle, Howard S...Clearwater, Fla.
Riddle, K. W.......Philadelphia, Pa.
Ridley, E. L...Thompsonville, Conn.
Ridley, W. H.......N. Adams, Mass.
Riebenack, M. 3rd...Philadelphia, Pa.
Ried, R. C..........Norristown, Pa.
Riegels, O. L........Cleveland, Ohio
Riegger, W. G....Washington, D. C.
Riehl, H. B.Newton Highlands, Mass.
Rieker, E. G., Jr...Philadelphia, Pa.
Rienks, G. W..........Denver, Colo.
Riesner, M.............Buffalo, N. Y.
Riethmiller, E. R....Jackson, Mich.
Rietz, C. A.....San Francisco, Calif.
Rietz, E. W............Chicago, Ill.
Rigby, E. J........Melbourne, Aust.
Rigdon, C.........New York, N. Y.
Riggs, H. E................
Maracaibo, Venezuela, S. A.
Riggs, J. D........Indianapolis, Ind.
Rightmire, B. G....Cambridge, Mass.
Riis, E..........Georgetown, S. C.
Riker, E...........Brooklyn, N. Y.
Riley, C. L.........New York, N. Y.
Riley, E. C........Washington, D. C.
Riley, J. C.........Cambridge, Mass.
Riley, R. A........New York, N. Y.
Riley, W. L...........Beverly, N. J.
Rilliet, J. L., Jr.......St. Louis, Mo.
Rimov, S..........Richmond, Calif.
Rindsberg, H. D.....Cincinnati, Ohio
Ring, R. A.....St. John, N. B., Can.
Ring, V. P............St. Louis, Mo.
Ringgenberg, H. I...E. Chicago, Ind.
Ringwald, E. A.....Chillicothe, Ohio
Rink, G. W............Reading, Pa.
Riopelle, C. P..........Chicago, Ill.
Riordan, J. M........Detroit, Mich.
Ripken, W. H.......Fairmont, Minn.
Ripley, C. B.....New Bedford, Mass.
Ripley, C. T...........Chicago, Ill.
Ripley, E. B., Jr...Waterbury, Conn.
Ripley, F. D........Keystone, W. Va.
Ripley, K. C......Washington, D. C.
Ripley, R. L...........Chicago, Ill.
Rippe, C...................
Puerto Berrio, Colombia, S. A.
Ripy, E. W......Lawrenceburg, Ky.
Riser, V. O........New York, N. Y.
Riss, G. A..........Cleveland, Ohio
Risteen, H. W......Houghton, Mich.
Ritchie, A. P........Leicester, Eng.
Ritchie, P...........Millville, N. J.
Ritchings, R. H....Cambridge, Mass.
Ritnour, L. C.........Natchez, Miss.
Rittelmeyer, J. M.......Atlanta, Ga.
Rittenhouse, L. H.....Haverford, Pa.
Ritter, H..........Cincinnati, Ohio
Ritter, H. P........Cincinnati, Ohio
Ritter, K.............Chicago, Ill.
Ritter, Paul A., Jr.....Houston, Tex.
Ritter, Paul Alex....Melbourne, Fla.
Ritter, W. F........Milwaukee, Wis.
Ritter, W. T..........Chicago, Ill.
Rittman, W. F.........Pittsburgh, Pa.
Rive, L. H.......Hollis, L. I., N. Y.
Rivett, E............Allerton, Mass.
Rivoira, E. J.......York Village, Me.
Rix, C. N..........E. Lansing, Mich.
Rizzo, J. F.........New York, N. Y.
Rizzuto, A..........Brooklyn, N. Y.
Roach, J. W.......Whittenberg, Tex.
Robb, A. R.........New York, N. Y.
Robb, C. A....Edmonton, Alta., Can.
Robb, D. W....Amherst, N. S., Can.
Robba, W. F.......New York, N. Y.
Robbins, H. A.........Brooklyn, N. Y.
Robbins, I. P...........Toledo, Ohio
Robbins, J. F.......New York, N. Y.
Robbins, R. W.......Belvidere, Kan.
Robbins, W. F......Worcester, Mass.
Robbs, W. H....Bayside, L .I., N. Y.
Robe, G. A.........Montclair, N. J.
Robert, J..............Chicago, Ill.
Robert, J. H.........Manhattan, Kan.
Robert, J. M........New Orleans, La.
Robert, L. W., Jr..Washington, D. C.
Robert, P......Niagara Falls, N. Y.
Roberton, J., Jr........Chicago, Ill.
Roberts, Arthur.....New York, N. Y.
Roberts, Arthur, Jr...Lynchburg, Va.
Roberts, A. L.......New York, N. Y.
Roberts, A. P.......New York, N. Y.
Roberts, A. R...Montreal, Que., Can.
Roberts, C.............Chicago, Ill.
Roberts, C. H...........Library, Pa.
Roberts, C. P.......Columbus, Ohio
Roberts, C. R.........Belleville, Ill.
Roberts, D. S........Elizabeth, N. J.
Roberts, Edw. D.......London, Eng.
Roberts, Edw. H.....W. Lynn, Mass.
Roberts, Edwin D.....Detroit, Mich.
Roberts, F. G.........Cleveland, Ohio
Roberts, H. L.........Corsciana, Tex.
Roberts, J......Montreal, Que., Can.
Roberts, J. D., Jr.Salt Lake City, Utah
Roberts, J. F.......Knoxville, Tenn.
Roberts, J. H.......Waterbury, Conn.
Roberts, Jas. L...Schenectady, N. Y.
Roberts, John L., Jr.Philadelphia, Pa.
Roberts, J. T..........Chicago, Ill.
Roberts, M. H.......Englewood, N. J.
Roberts, P., Jr.........Narberth, Pa.
Roberts, P. G......E. Pittsburgh, Pa.
Roberts, R. F......New York, N. Y.
Roberts, S. B.......Cumberland, Md.
Roberts, T. H......New Orleans, La.
Roberts, W...........Lancaster, Pa.
Roberts, W. H.......Memphis, Tenn.
Robertshaw, C. W...Youngwood, Pa.
Robertson, B..........Boston, Mass.
Robertson, B. J...Minneapolis, Minn.
Robertson, C. E.....Milwaukee, Wis.
Robertson, G. A..........Atlanta, Ga.
Robertson, J. D...N. Dighton, Mass.
Robertson, J. M.......Houston, Tex.
Robertson, N. F......Brooklyn, N. Y.
Robertson, R. R...Los Angeles, Calif.
Robeson, A. M.........London, Eng.
Robinson, A. L.......Syracuse, N. Y.
Robinson, C. H.....Columbus, Ohio
Robinson, C. Snelling..........
Youngstown, Ohio
Robinson, C. Stanley..........
Wilmington, Del.
Robinson, D. P.....Philadelphia, Pa.
Robinson, E. A..Montreal, Que., Can.
Robinson, E. J........Milford, Mass.
Robinson, E. L....Schenectady, N. Y.
Robinson, E. M...Minneapolis, Minn.
Robinson, E. P........Malden, Mass.
Robinson, F. N.......Longview, Tex.
Robinson, G.........Louisville, Ky.
Robinson, H. H.......Buffalo, N. Y.
Robinson, H. M.........Dallas, Tex.
Robinson, H. R.........Detroit, Mich.
Robinson, I. V........London, Eng.
Robinson, J.........New York, N. Y.
Robinson, J. H.........Cismont, Va.
Robinson, J. L.......Muskegon, Mich.
Robinson, J. R.......Zelienople, Pa.
Robinson, J. S.......Cleveland, Ohio
Robinson, L. G......Cincinnati, Ohio
Robinson, M. B......Cleveland, Ohio
Robinson, M. G.....Bloomfield, N. J.
Robinson, P. A.....Philadelphia, Pa.
Robinson, R. R...Los Angeles, Calif.
Robinson, Ted. H.......Chicago, Ill.
Robinson, Theo. H...New York, N. Y.
Robinson, W. E.....New York, N. Y.
Robinson, W. M.......Cleveland, Ohio
Robinson, W. P...Toronto, Ont., Can.
Robson, W. J.....Toronto, Ont., Can.
Roby, C. F........Birmingham, Eng.
Rockafield, N. L.......Seattle, Wash.
Rockefeller, H. E....New York, N. Y.
Rockefeller, J. A......Newark, N. J.
Rockefeller, W. C....Pasadena, Calif.
Rocklin, I. J........Sioux City, Iowa
Rockwell, H. P., Jr....Newark, N. J.
Rockwell, R. L........Seattle, Wash.
Rockwell, S. F.....N. Andover, Mass.
Rockwell, T. F........Pittsburgh, Pa.
Rockwell, W. P......Pittsburgh, Pa.
Rockwood, G. I.....Worcester, Mass.
Roddy, F. M.......Kingsport, Tenn.
Rodemeyer, H..........Detroit, Mich.
Rodenbaugh, D. I....Zanesville, Ohio
Rodenbaugh, H. N..............
St. Augustine, Fla.
Roderick, E. M......New York, N. Y.
Rodger, W. N......New York, N. Y.
Rodgers, A. C.........Norwood, Mass.
Rodgers, H. P.......Cleveland, Ohio
Rodgers, W. C.........Pampa, Tex.
Rodgers, W. M........St. Louis, Mo.
Rodin, M. B..........S. Bend, Ind.
Rodman, N.........New York, N. Y.
Rodman, R. W.....New York, N. Y.
Rodman, W. L...Santa Monica, Calif.
Rodnite, J. J.....New York, N. Y.
Roe, J. W.........New York, N. Y.
Roe, R. C..........New York, N. Y.
Roede, C. B........Brooklyn, N. Y.
Roedel, J. K..........Casper, Wyo.
Roehm, J. M.......New Orleans, La.
Roemer, H......San Francisco, Calif.
Roemmele, H. F....New York, N. Y.
Roepnack, A. F.....Cleveland, Ohio
Roesch, D..............Chicago, Ill.
Roesch, F. P............Chicago, Ill.
Roesel, A. F.....Elizabethton, Tenn.
Roesel, L. C..........Savannah, Ga.
Roeseler, E. F........Billings, Mont.
Roesky, R. H...........Omaha, Neb.
Roetzer, A. A..........Everett, Mass.
Rogers, A. A..Moose Jaw, Sask., Can.
Rogers, A. B.......New York, N. Y.
Rogers, B. F..........Kingston, Pa.
Rogers, D. A..........Hopewell, Va.
Rogers, F. H.......Philadelphia, Pa.
Rogers, George Alexander.......
Dobbs Ferry, N. Y.
Rogers, Geo. Arthur.....Omaha, Neb.
Rogers, G. B.........New York, N. Y.
Rogers, G. E...........Dover, N. J.
Rogers, H. S.......Philadelphia, Pa.
Rogers, J. A..Port Arthur, Ont., Can.
Rogers, J. E.....Toronto, Ont., Can.
Rogers, J. H......Washington, D. C.
Rogers, L. C.....Grand Rapids, Mich.
Rogers, N. S.......Port Huron, Mich.
Rogers, P. K.....New Britain, Conn.
Rogers, R. E., Jr.....Cranford, N. J.
Rogers, R. W..........Oil City, Pa.
Rogers, W. A.....Des Moines, Iowa
Rogers, W. S...Malverne, L. I., N. Y.
Rogerson, J. B.......El Dorado, Ark.
Rogoff, J..........New York, N. Y.
Rohlin, K. W.........Camden, N. J.
Rohlin, V. A.......Philadelphia, Pa.
Rohrer, A. L.......Maplewood, N. J.
Rohrhurst, W.....Bound Brook, N. J.
Rohrich, H. A............Alton, Ill.
Roig, J. A..........Humacao, P. R.
Rojahn, J. S........Waynesboro, Pa.
Roland, P. W..................
Jackson Heights, L. I., N. Y.
Rolland, G. A......Dorchester, Mass.
Rolle, C...........New York, N. Y.
Rollins, F. S., Jr....Richmond, Calif.
Rollins, L. M.....Minneapolis, Minn.
Rollins, W. B.......Kansas City, Mo.
Rollman, M. E......Cincinnati, Ohio
Rollow, J. G.....Los Angeles, Calif.
Romaine, M..........Cincinnati, Ohio
Roman, H......Bucharest, Roumania
Romanach, J. A.......Havana, Cuba
Romann, J. H.........Louisville, Ky.
Romanow, F. F.....New York, N. Y.
Romberg, G. S......Drumright, Okla.
Romero, C............Havana, Cuba
Romigh, O. L........Brooklyn, N. Y.
Ronan, J. T.........Martinez, Calif.
Ronkainen, V. A...............
Huntington Station, L. I., N. Y.
Ronowski, R. P.......La Grange, Ill.
Roome, G. R. S...Asbury Park, N. J.
Roop, F. S., Jr.......Blacksburg, Va.
Rooste, E. E..........Auburn, Aust.
Root, E. L.......Watertown, Mass.
Root, F. J.........Ridgewood, N. J.
Root, G. E.............Detroit, Mich.
Root, J. J., Jr..........Chicago, Ill.
Roper, C. G.........Pittsburgh, Pa.
Rorabeck, C............Chicago, Ill.
Rorvig, K. C........New York, N. Y.
Rosborough, C. R........Moline, Ill.
Roscher, A. M.........Boston, Mass.
Roscoe, E. S.........Rochester, N. Y.
Roscoe, H. W.......New York, N. Y.
Rose, C. B..........Philadelphia, Pa.
Rose, C. G......Niagara Falls, N. Y.
Rose, F. W.......Minneapolis, Minn.
Rose, J. H............Bradford, Pa.
Rose, L. J........Washington, D. C.
Rose, R. A...........Madison, Wis.
Rosebrugh, C. M.......Houston, Tex.
Rosen, C. G. A.......Oakland, Calif.
Rosen, M.........Sierra Madre, Calif.
Rosenak, I.........E. Chicago, Ind.
Rosenbaum, R. V....Aberdeen, Wash.
Rosenberg, E. C.....Milwaukee, Wis.
Rosenberg, H.......New York, N. Y.
Rosenberg, L. W........Chicago, Ill.
Rosenberg, S.......New York, N. Y.
Rosenblatt, M. C...Philadelphia, Pa.

Rosenblum, E. S.....Cleveland, Ohio
Rosencrants, F. H...New York, N. Y.
Rosener, L. S....San Francisco, Calif.
Rosenfelt, S. D........Kirkwood, Mo.
Rosenstein, J. H....New York, N. Y.
Rosenthal, J. A.......Newark, N. J.
Rosenthal, R.......New York, N. Y.
Rosenzweig, S.......New York, N. Y.
Rosing, W. H. V......St. Louis, Mo.
Rosmait, J. A.......Milwaukee, Wis.
Ross, C...........Washington, D. C.
Ross, C. A..............Piqua, Ohio
Ross, C. C.........Rochester, N. Y.
Ross, D. P.........New York, N. Y.
Ross, F. E............Oakland, Calif.
Ross, H. E............Chicago, Ill.
Ross, H. J. M..............York, Pa.
Ross, H. L..........Milwaukee, Wis.
Ross, J. A., Jr.......Potsdam, N. Y.
Ross, J. C............St. Louis, Mo.
Ross, J. H........Port Sulphur, La.
Ross, J. O..........New York, N. Y.
Ross, J. W.............Ashland, Ky.
Ross, T. H........Los Angeles, Calif.
Ross, W. T............Roanoke, Va.
Rosseau, F. V.............Kiln, Miss.
Rossee, C..........Wilmington, Del.
Rossetto, L..........Philadelphia, Pa.
Rossheim, D. B.......Teaneck, N. J.
Roth, E...........Connersville, Ind.
Roth, G. L..........Philadelphia, Pa.
Roth, Henry..........Lancaster, Pa.
Roth, Herbert.......New York, N. Y.
Roth, P. V.........Philadelphia, Pa.
Roth, W. E.......Hackensack, N. J.
Rothgeb, R. M...........Raleigh, N. C.
Rothmaler, O.......New York, N. Y.
Rothmeyer, W. R.........Ames, Iowa
Rothschild, W. G....New York, N. Y.
Rotter, M............St. Louis, Mo.
Rouch, E. A......Phillipsburg, N. J.
Roudebush, R. E.........Ames, Iowa
Roundy, E. O...........Akron, Ohio
Roush, H. F.............Lima, Ohio
Rowan, J. J......Ottawa, Ont., Can.
Rowan, R. L.......Philadelphia, Pa.
Rowand, E. M., Jr..Philadelphia, Pa.
Rowe, H...............Boston, Mass.
Rowe, H. E.........New York, N. Y.
Rowell, K. B.......New York, N. Y.
Rowland, D. J.......New York, N. Y.
Rowland, R. H.......Frogmore, S. C.
Rowland, R. W......New Castle, Pa.
Rowland, T. F., Jr....Brooklyn, N. Y.
Rowley, E. R..........Chicago, Ill.
Rowley, F. B.....Minneapolis, Minn.
Rowland, T. F., Jr...Brooklyn, N. Y.
Rowley, M. C........Pittsburgh, Pa.
Rowley, R. L..........Oakland, Calif.
Rowse, W. C......Los Angeles, Calif.
Royer, C. R.........Coshocton, Ohio
Royer, D. L........New York, N. Y.
Royle, V. E..........Paterson, N. J.
Roys, F. W.........Worcester, Mass.
Roys, L....................Moline, Ill.
Rozenberg, H. W...Williamsport, Pa.
Rozett, W., Jr......New York, N. Y.
Rubenkoenig, H...W. Lafayette, Ind.
Rubinowitz, L.....Washington, D. C.
Ruch, A. J..........New York, N. Y.
Ruck, G............Philadelphia, Pa.
Ruckman, J. H.........Topeka, Kan.
Rudd, W. C..........Detroit, Mich.
Ruddy, W.........Westfield, N. J.
Rude, R. L.....Toronto, Ont., Can.
Rudgers, A. J.....Washington, D. C.
Rudolf, G. A.........Oakland, Calif.
Rudolphi, F.........New York, N. Y.
Rue, H. E..............Newark, N. J.
Rue, J. D......Niagara Falls, N. Y.
Rued, F. H......San Francisco, Calif.
Ruegg, C..........Milwaukee, Wis.
Ruemelin, R.........Milwaukee, Wis.
Ruess, M. E.........Milwaukee, Wis.
Ruetenik, B. P.......Cleveland, Ohio
Ruetschi, R. R.........Saltville, Va.
Ruf, L. J...............Omaha, Neb.
Ruff, Henry............Topeka, Kan.
Ruff, Herbert.......Philadelphia, Pa.
Rugge, G. J.........New York, N. Y.
Rugh, J. M.........Providence, R. I.
Ruhloff, F. C......S. Milwaukee, Wis.
Ruiter, R. N.........Birmingham, Ala.
Ruiz, A. L.......Schenectady, N. Y.
Ruiz, J. J.........Wyandotte, Mich.
Rule, P...............Chicago, Ill.
Rulfs, C. H............St. Louis, Mo.
Rumble, V. A...San Francisco, Calif.
Runge, R. F.......Philadelphia, Pa.
Runtagh, R. R..........Kingston, Pa.
Runyon, F. O.........Newark, N. J.
Runyon, M. E......Maplewood, N. J.
Rupard, H.........Indianapolis, Ind.
Rupp, M. E..........Brooklyn, N. Y.
Ruppel, H. W.......Cleveland, Ohio
Rusch, K...........Milwaukee, Wis.
Rush, C. W.........Waterbury, Conn.
Rush, W. C.............Dallas, Tex.
Rushey, D. D........Syracuse, N. Y.
Rushmore, D. B......New York, N. Y.
Rusho, E. J............Honolulu, T. H.
Rusie, W. F.....Corona, L. I., N. Y.
Russ, J. M..........Iowa City, Iowa
Russell, E. W.........Pensacola, Fla.
Russell, F. E....San Francisco, Calif.
Russell, F. L..........Newark, N. J.
Russell, H. H., Jr...Cape Charles, Va.
Russell, J. J........New York, N. Y.
Russell, K. F........Claremont, Calif.
Russell, R. H.........Lawrence, Kan.
Russell, R. J...............York, Pa.
Russell, W. B..........Boston, Mass.
Rust, G. M..........Pittsburgh, Pa.
Rust, H. P.........Philadelphia, Pa.
Rust, M. D..........Memphis, Tenn.
Rust, S. M., Jr.......Pittsburgh, Pa.
Rutherford, F. C....Milwaukee, Wis.
Rutherford, M. H.......Chicago, Ill.
Rutter, J. A......Phillipsburg, N. J.
Ryan, B. E............Jasper, Ark.
Ryan, E. J............Dundalk, Md.
Ryan, F. M..Welwyn Garden City, Eng.
Ryan, Jas. E........Haverhill, Mass.
Ryan, John E....Schenectady, N. Y.
Ryan, J. F., Jr......Berkeley, Calif.
Ryan, J. H..........Pittsburgh, Pa.
Ryan, J. J........Minneapolis, Minn.
Ryan, S. G...Prince Bay, S. I., N. Y.
Ryan, W. F...........Boston, Mass.
Ryan, W. J........New York, N. Y.
Ryan, W. R.........Haworth, N. J.
Rybkin, I............London, Eng.
Ryder, E. I...........Arlington, Va.
Ryder, G. C.........Plainfield, N. J.
Ryder, J. C.........Montclair, N. J.
Ryder, K. F............Ancon, C. Z.
Ryder, M. W.......Cambridge, Mass.
Ryding, H. C......Birmingham, Ala.
Rynda, J. T......Minneapolis, Minn.

S

Saalfrank, J. M.....Philadelphia, Pa.
Saathoff, G. W......New York, N. Y.
Sabin, A. H....Flushing, L. I., N. Y.
Sachdev, M. L..........Delhi, India
Sachs, J............Hartford, Conn.
Sack, M.............Louisville, Ky.
Sackett, R. L......State College, Pa.
Sada, L. G...........Monterey, Mex.
Sadler, C. R.........Beaver Falls, Pa.
Sadler, H. C........Ann Arbor, Mich.
Sadler, J. H.........Mt. Holly, N. C.
Saenger, G. W......Footscray, Aust.
Sage, D................Kearny, N. J.
Sager, E. H...........St. Louis, Mo.
Sager, N. W............McGill, Nev.
Sague, S. R..........Cleveland, Ohio
Sagui, A. J...........Arlington, Va.
Saharoff, A. V.........Buffalo, N. Y.
Sahmel, V..........New York, N. Y.
Sahrbeck, C. J., Jr..Brooklyn, N. Y.
Sailer, J. Jr........Philadelphia, Pa.
St. Clair, C. D...........Moline, Ill.
St. Clair, F. G.......E. St. Louis, Ill.
St. Clair, O. A.........Lubbock, Tex.
St. Germain, R. J..Breaux Bridge, La.
St. John, C. E..........Scranton, Pa.
St. John, E. D.........Wichita, Kan.
St. John, S. B.......Worcester, Mass.
St. Lawrence, J...............Erie, Pa.
St. Lawrence, L. H....Waban, Mass.
Salbador, H. W...Wilmington, Calif.
Saliba, E. M..........Lawrence, Mass.
Salisbury, A...........Midland, Mich.
Salisbury, D. W.....New York, N. Y.
Salisbury, F. R......Rochester, N. Y.
Salisbury, H. G............Troy, N. Y.
Salisbury, J. K....Schenectady, N. Y.
Salisbury, J. Q.........Dayton, Ohio
Salisbury, R. W..........Dallas, Tex.
Salkover, N. M......Cincinnati, Ohio
Salley, E. M., Jr..........Enka, N. C.
Sallows, E........Los Angeles, Calif.
Salma, E. A........New York, N. Y.
Salmon, J. H...........St. Louis, Mo.
Salmon, P. A.......New York, N. Y.
Salmonsen, R.......New York, N. Y.
Salo, E. A..........New York, N. Y.
Saltzman, Auguste Louis, Jr....
Newark, N. J.
Saltzman, Auguste Leopold......
Orange, N. J.
Salvatore, R.........Lyndhurst, N. J.
Salzman, C. E.......Indianapolis, Ind.
Samans, W..........Philadelphia, Pa.
Samoiloff, L. A.....Philadelphia, Pa.
Sampson, E. M........Columbus, Ohio
Sampson, F. A....Ottawa, Ont., Can.
Sampson, H. H.....New York, N. Y.
Sampson, J. J.......New York, N. Y.
Sampson, W. F.....New York, N. Y.
Sampter, H. C......Philadelphia, Pa.
Sams, B. J...........Savannah, Ga.
Sams, J. H., Jr.Clemson College, S. C.
Samuels, T. W.......Bardstown, Ky.
Sanborn, E. E.......New York, N. Y.
Sandager, W., Jr.....Rumford, R. I.
Sanders, G. E.......New York, N. Y.
Sanders, J......San Francisco, Calif.
Sanders, J. C........New York, N. Y.
Sanders, N.......Chattanooga, Tenn.
Sanders, W. C..........Canton, Ohio
Sanderson, E. S.....Waterbury, Conn.
Sanderson, R. R.....New York, N. Y.
Sandfort, J. F..........Dayton, Ohio
Sando, W. J.............Chicago, Ill.
Sanera, M. E.........Cleveland, Ohio
Sanfillippo, S. E..........Newark, N. J.
Sanford, G. R.......New York, N. Y.
Sanford, L. R.....Washington, D. C
Sangster, W....Peterboro, Ont., Can.
Santamaria, I. J...............
Central Preston, Cuba
Santry, J. V........New York, N. Y.
Santti, K. E...........Detroit, Mich.
Saponara, D........New York, N. Y.
Saracino, F. E...........Chicago, Ill.
Saragovitz, H. M...Philadelphia, Pa.
Sardana, A. N.........Lucknow, India
Sargent, F. W......New York, N. Y.
Sargent, R................Chicago, Ill.
Sargent, R. N.........Plainfield, N. J.
Sargent, W. D..............Miami, Fla.
Sartorius, W. J..Port Ivory, S. I., N. Y.
Sarvis, A. L...........W. Allis, Wis.
Sass, C. H.........Cambridge, Mass.
Sasso, C. C..............Clinton, Ind.
Satterfield, H. E.......Raleigh, N. C.
Sattler, F. C., Jr....Providence, R. I.
Saucier, J. H., Jr.........Dallas, Tex.
Sauer, R. L............Detroit, Mich.
Sauers, J. A.......W. Lafayette, Ind.
Saulson, S..............Detroit, Mich.
Saundararajan, A..Dhanushkodi, India
Saunders, A. B..San Francisco, Calif.
Saunders, C. B.....Wyandotte, Mich.
Saunders, F. S......Greenville, Mich.
Saunders, W. H.....New Orleans, La.
Saunier, W. P...........Reading, Pa.
Saurwein, G. K.....Cambridge, Mass.
Sauter, W. V.......Philadelphia, Pa.
Savaro, V. G.............Scranton, Pa.
Saville, A. J...........Richmond, Va.
Savoye, C. U........New York, N. Y.
Savrda, C. M........New York, N. Y.
Sawdon, W. M.........Ithaca, N. Y.
Sawdon, W. W........Buffalo, N. Y.
Sawford, F....Vancouver, B. C., Can.
Sawin, H. A.....San Francisco, Calif.
Sawyer, A. J.........Nederland, Tex.
Sawyer, H. T..........Pittsburgh, Pa.
Sawyer, R. T.......New York, N. Y.
Sawyer, W. H......New York, N. Y.
Saxby, L. E....Upper Montclair, N. J.
Sayers, W. W............Chicago, Ill.
Sayles, B. J..........Wilkinsburg, Pa.
Sayles, M. A..............Omaha, Neb.
Saylor, D. C...........Pittsburgh, Pa.
Sayre, M. F.......Schenectady, N. Y.
Sayre, R. L...........Cincinnati, Ohio
Sburlino, P..............Dayton, Ohio
Scanlon, H. C..........Brooklyn, N. Y.
Scarbrough, G. F.........Atlanta, Ga.
Scarpino, W. J....Sacramento, Calif.
Schaaf, G. C..........Brooklyn, N. Y.
Schaake, W.........E. Pittsburgh, Pa.
Schaal, N. J...........Seattle, Wash.
Schadeck, E. W...........Dallas, Tex.
Schaefer, C. B.......New York, N. Y.
Schaefer, C. T..........St. Louis, Mo.
Schaefer, F. LeR..Charleston, W. Va.
Schaefer, F. R.............Niles, Ohio
Schaefer, H..............Tulsa, Okla.
Schaeuble, C. H.......Cincinnati, Ohio
Schafer, R. A..........Richmond, Ind.
Schafer, S. P........Jersey City, N. J.
Schafer, T. W. D....Providence, R. I.
Schaff, F. A..........New York, N. Y.
Schaffer, B............New York, N. Y.
Schaffert, G. A......Spindale, N. C.
Schaffner, J. W.......Syracuse, N. Y.
Schainker, A.............St. Louis, Mo.
Schaller, A...........Wellsville, N. Y.
Schaller, N. C.......Philadelphia, Pa.
Schaller, W. F............Chicago, Ill.
Schanze, C. R......Philadelphia, Pa.
Schaphorst, W. F..............
Atlantic Highlands, N. J.
Schapiro, P.........Brooklyn, N. Y.
Schapiro, S. B........Texas City, Tex.
Scharnagel, H. J....New York, N. Y.
Scharnberg, H. J. B..Clewiston, Fla.
Scharnberg, L. N....Pittsburgh, Pa.
Scharpenberg, C. C..Bakersfield, Calif.
Schaub, H. W...........Kearny, N. J.
Schauer, N. A.......Wauwatosa, Wis.
Schauffler, D. J.....Bloomfield, N. J.
Schaum, A. H....University City, Mo.
Schaum, O. W......Philadelphia, Pa.
Schaum, P. F.......Cincinnati, Ohio
Schaurte, W. T......Neuss, Germany
Schechter, J. P........Detroit, Mich.
Scheckenbach, J. A. V..........
New York, N. Y.
Scheel, H. V. R.....New York, N. Y.
Scheffel, P...............Irwin, Pa.
Scheffler, F. A......Glen Ridge, N. J.
Scheibel, A. H.........Boston, Mass.
Scheidt, H. J..Bayville, L. I., N. Y.
Schein, A...........Brooklyn, N. Y.
Schell, A. E.........Rochester, N. Y.
Schell, E. H.......Cambridge, Mass.
Schell, F. B., Jr.........Marietta, Ohio
Schell, H. B.........Brooklyn, N. Y.
Schell, W. A...........Le Roy, N. Y.
Schellens, E. L.....Englewood, N. J.
Schenck, C...........Bethlehem, Pa.
Schenck, J. J.........St. Louis, Mo.
Schenck, T...........Brooklyn, N. Y.
Schenewerk, J. F..........Dallas, Tex.
Schenk, E. M.......Englewood, N. J.
Schepman, W. G...Indianapolis, Ind.
Scher, G...............Newark, N. J.
Scherer, F. R.......Rochester, N. Y.
Scherer, H. A. G......Newark, N. J.
Scherner, J........Springfield, Mass.
Schick, D. F., Jr...Philadelphia, Pa.
Schick, H. L........Brooklyn, N. Y.
Schickedanz, L. H......Gary, W. Va.
Schickel, N. H...........Ithaca, N. Y.
Schier, O. B........New York, N. Y.
Schieren, G. A.......New York, N. Y.
Schildhauer, E..Santa Monica, Calif.
Schiller, W. A.........St. Louis, Mo.
Schilling, B..........New York, N. Y.
Schillinger, C.........Hazleton, Pa.
Schlachter, C. H....Montclair, N. J.
Schlank, E..........New York, N. Y.
Schlather, M. F........Cibolo, Tex.
Schlatter, R...........St. Louis, Mo.
Schlayer, E. G.......New York, N. Y.
Schlegel, N. C......Ridgewood, N. J.
Schleser, E.............Freeport, Tex.
Schlesinger, G.....Brussels, Belgium
Schlick, L. F.......New York, N. Y.
Schlink, F. J.......Washington, N. J.
Schlitt, J. L........Stamford, Conn.
Schlobach, G. F.......Endicott, N. Y.
Schloss, N. L.......New York, N. Y.
Schluderberg, C. C....Baltimore, Md.
Schmalhurst, G. H...Cleveland, Ohio
Schmarje, C. F...Cabin Creek, W. Va.
Schmeisser, E. G....Baltimore, Md.
Schmeisser, W. J.......Evanston, Ill.
Schmeltzer, J. E..Washington, D. C.
Schmid, A. H..Flushing, L. I., N. Y.
Schmid, A. W......Springfield, Ohio
Schmid, B. J.....Schenectady, N. Y.
Schmid, F. G.........Dubuque, Iowa
Schmid, W. A., Jr....Cleveland, Ohio
Schmid, W. E.........Paris, France
Schmidbauer, W......Alameda, Calif.
Schmidt, A. A....Los Angeles, Calif.
Schmidt, A. G....Los Angeles, Calif.
Schmidt, C. G. A., Jr.Harrisburg, Pa.
Schmidt, E. A..........Hazleton, Pa.
Schmidt, E. C...........Urbana, Ill.
Schmidt, E. F...........Dallas, Tex.
Schmidt, E. H.......New York, N. Y.
Schmidt, F. J.......Memphis, Tenn.
Schmidt, F. W.......Brooklyn, N. Y.
Schmidt, G. G.......New York, N. Y.
Schmidt, G. W......Mishawaka, Ind.
Schmidt, H. E............Bristol, Pa.
Schmidt, H. F.........Boston, Mass.
Schmidt, H. P......Brooklyn, N. Y.
Schmidt, J. F....Washington, D. C.
Schmidt, J. H...........Chicago, Ill.
Schmidt, K.......Elizabethton, Tenn.
Schmidtchen, R. P..New York, N. Y.
Schmitt, B. A...........Chicago, Ill.
Schmitt, H. O.......Philadelphia, Pa.
Schmitz, E. H..........Boston, Mass.
Schnackel, H. G.....Elizabeth, N. J.
Schneider, B. R....Lyndhurst, N. J.
Schneider, C.......Washington, D. C.
Schneider, C. A....New York, N. Y.
Schneider, F. H.......Royersford, Pa.
Schneider, M. L.....New York, N. Y.
Schneider, P. J.....Roosevelt, N. Y.
Schneider, R. S....New York, N. Y.
Schneider, W......Waterbury, Conn.
Schneider, W. C.......Windsor, Conn.
Schneitter, L.......New York, N. Y.
Schnepp, C. F..Ridgefield Park, N. J.
Schnitzer, S.............Chicago, Ill.
Schobeck, A. E.....Jamestown, N. Y.
Schoder, E. F.......New York, N. Y.
Schoen, J. E.........Milwaukee, Wis.
Schoenborn, W. E..Washington, D. C.
Schoenfeld, D. M.......Chicago, Ill.
Schoenfeld, E., Jr....Montrose, N. Y.
Schoenfeldt, W. C..New York, N. Y.
Schoenijahn, R. P..Wilmington, Del.
Schoening, F. C....New York, N. Y.
Schoenky, O. B....Los Angeles, Calif.

Schoephoester, K. F....Denver, Colo.
Schoerke, D. A.........Petrolia, Pa.
Schoessow, G. J.....Barberton, Ohio
Schofield, W. R....Philadelphia, Pa.
Scholefield, C. W....LaHabra, Calif.
Scholes, D. R...........Chicago, Ill.
Scholtze, H. J.......Berkeley, Calif.
Schonitzer, R. I......Cleveland, Ohio
Schooley, O. L......Royal Oak, Mich.
Schorling, H. F....New York, N. Y.
Schowalter, C. H..Philadelphia, Pa.
Schrader, T. O., Jr........Erie, Pa.
Schranz, C. A......Philadelphia, Pa.
Schranz, F. G......Philadelphia, Pa.
Schreck, H..............Beloit, Wis.
Schreckenberger, E...Brooklyn, N. Y.
Schreiber, C. T.....New York, N. Y.
Schreiber, H. V....Washington, D. C.
Schreiber, J. W......Pittsburgh, Pa.
Schrenk, L. J.......Detroit, Mich.
Schroder, J. H.......Coatesville, Pa.
Schroeder, B...........Chicago, Ill.
Schroeder, H......New York, N. Y.
Schroeder, J. F........Chicago, Ill.
Schroeder, O....San Francisco, Calif.
Schroeer, R. A.........St. Louis, Mo.
Schubert, A. G....Watervliet, N. Y.
Schubert, E. H......Cincinnati, Ohio
Schubert, F. J..Lynbrook, L. I., N. Y.
Schubert, F. R........Detroit, Mich.
Schubert, G. W.....Milwaukee, Wis.
Schubert, W. E.......Appleton, Wis.
Schucany, O. W.........Dallas, Tex.
Schueler, L. B.......New York, N. Y.
Schuerman, E. L....Leonardo, N. J.
Schuette, R. W......Pittsburgh, Pa.
Schuetz, F. F.......New York, N. Y.
Schuetz, W. V....Hamburg, Germany
Schuetze, G......Stuttgart, Germany
Schullstrom, T.....New York, N. Y.
Schulte, M. J. L....New York, N. Y.
Schultz, A. W..........Chicago, Ill.
Schultz, H. L.......Kenmore, N. Y.
Schultz, K. W....Minneapolis, Minn.
Schultz, O. C..........Toledo, Ohio
Schultz, R. H......Brooklyn, N. Y.
Schultz, W. F....Los Angeles, Calif.
Schultze, G. W........Hopewell, Va.
Schulz, D. D..........Scranton, Pa.
Schulz, E..........Berlin, Germany
Schulz, G. E.........Auburn, N. Y.
Schulz, L. E.........Oakland, Calif.
Schum, E. C.........Milwaukee, Wis.
Schumann, A. P.......Kenton, Ohio
Schumann, E. A., Jr............ Port Huron, Mich.
Schumb, M. T......N. Quincy, Mass.
Schupp, A. A........Saginaw, Mich.
Schur, M. O...........Berlin, N. H.
Schuricht, C. O., Jr............ Hollis, L. I., N. Y.
Schussler, W. H....Philadelphia, Pa.
Schuster, A. W........Buffalo, N. Y.
Schuyler, W. A.....New York, N. Y.
Schwab, C. M.......New York, N. Y.
Schwab, G..........Elizabeth, N. J.
Schwanbeck, H. A......Chicago, Ill.
Schwanhausser, E. J...Buffalo, N. Y.
Schwarte, J..Copper Cliff, Ont., Can.
Schwartz, A.......Jersey City, N. J.
Schwartz, A. A......New York, N. Y.
Schwartz, A. J....Washington, D. C.
Schwartz, F. L......Brooklyn, N. Y.
Schwartz, Harry Adolph........ Cleveland, Ohio
Schwartz, Harry Albert........ Montpelier, Ohio
Schwartz, L. P..Webster Groves, Mo.
Schwartz, S. B.....New Orleans, La.
Schwartz, S. T......New York, N. Y.
Schwarz, Eugene A....Buffalo, N. Y.
Schwarz, Emil A......St. Louis, Mo.
Schwarz, E. H......New York, N. Y.
Schwarz, F. H.......Lawrence, Mass.
Schwarz, M..........St. Louis, Mo.
Schwarzwalder, R. F.......... Grantwood, N. J.
Schwebel, E. C......Cincinnati, Ohio
Schweier, A........Knoxville, Tenn.
Schweinhagen, E. A....Toledo, Ohio
Schweisthal, F. G......Chicago, Ill.
Schweitzer, P. H..State College, Pa.
Schweitzer, R. R......Norfolk, Va.
Schweitzer, V.......Montclair, N. J.
Schweizer, C. L.......Brooklyn, N. Y.
Schweizer, Paul Ernest.Auburn, N. Y.
Schweizer, Paul Eugene.Newark, N. J.
Schwendener, H. G........... Bowling Green, Ky.
Schwenke, H. O. L..New York, N. Y.
Schwenn, C. A.........Detroit, Mich.
Schwenn, E..........Warwick, N. Y.
Schwennesen, H. A....Elmira, N. Y.
Schwerin, F. H.......Pittsburgh, Pa.
Schwertfeger, A. J..Wilmington, Del.
Schwind, G.........Brooklyn, N. Y.
Scipio, L. A..Constantinople, Turkey

Scofield, L. W........Hartford, Conn.
Scorah, R. L........Columbia, Mo.
Scott, A. H......New Britain, Conn.
Scott, C...........Montclair, N. J.
Scott, C. F.......New Haven, Conn.
Scott, C. G., Jr......Eddystone, Pa.
Scott, D. C........Springfield, Mass.
Scott, D. H..........Cleveland, Ohio
Scott, E. C.............Ambler, Pa.
Scott, E. F..............Atlanta, Ga.
Scott, E. G..........Camden, N. J.
Scott, E. W.......Springfield, Mass.
Scott, G. E........New York, N. Y.
Scott, G. J........New York, N. Y.
Scott, H. F.......Framingham, Mass.
Scott, J. B........Philadelphia, Pa.
Scott, J. F..........Collingdale, Pa.
Scott, J. W.........Brooklyn, N. Y.
Scott, K. W..........Louisville, Ky.
Scott, L. L..........Kirkwood, Mo.
Scott, R. M........Providence, R. I.
Scott, Richard S....Philadelphia, Pa.
Scott, Rossiter S....New York, N. Y.
Scott, W. C.........Plainfield, N. Y.
Scott, W. E.......Jersey City, N. J.
Scott, W. G....Montreal, Que., Can.
Scott, W. O. C.Vancouver, B. C., Can.
Scott, W. R..........Pittsburgh, Pa.
Scott, W. W...........Houston, Tex.
Scott-Taggart, J..Frinton-on-Sea, Eng.
Scoville, W. E., Jr....Roselle, N. J.
Scranton, D. H.........Buffalo, N. Y.
Scribner, C. W......Honolulu, T. H.
Scrivener, R. H..Montreal, Que., Can.
Scrivenor, A.........Richmond, Va.
Scudder, H......Schenectady, N. Y.
Seagren, J............Oakland, Calif.
Seaman, H. B......Brooklyn, N. Y.
Seaman, J.............Toledo, Ohio
Searl, J..............Bayonne, N. J.
Searle, R. M.......Washington, D. C.
Searle, W. C..........Worcester, Mass.
Searle, W. F., Jr....Knoxville, Tenn.
Searles, E. F......New York, N. Y.
Sears, H. R......Los Angeles, Calif.
Sears, H. T........Bartlesville, Okla.
Seaton, R. A.........Manhattan, Kan.
Seaver, C. A................. Dongan Hills, S. I., N. Y.
Seaver, K..........Pittsburgh, Pa.
Sebald, L. E.........New York, N. Y.
Seckendorff, E. W....Columbus, Ohio
Sederholm, E. T..Los Angeles, Calif.
Sedgwick, E. H....New York, N. Y.
Sedgwick, H. A.....Milwaukee, Wis.
Sedlack, E. C......Dowagiac, Mich.
See, A. B..........New York, N. Y.
Seeber, R. R........Houghton, Mich.
Seeder, C..............Harvey, Ill.
Seekins, A. W..........Akron, Ohio
Seeley, L. E.......New Haven, Conn.
Seelig, A. E......New York, N. Y.
Seelig, L..............Chicago, Ill.
Seely, F. B..............Urbana, Ill.
Seely, W............Cleveland, Ohio
Seem, C. B..........Zionsville, Pa.
Seewer, E. U.........Columbus, Ind.
Sefcsik, L. J.....Jamaica, L. I., N. Y.
Segall, K. B..........Detroit, Mich.
Segaser, C. L.....Spring City, Tenn.
Segel, J...........Wilmington, Del.
Segl, W. E..........Hopewell, Va.
Segur, A. B..........Oak Park, Ill.
Seguso, O.................. Long Island City, N. Y.
Seib, W. A............Akron, Ohio
Seibel, C. C..........St. Louis, Mo.
Seibert, C. J.....Washington, D. C.
Seibert, S. H........Westfield, N. J.
Seichter, F. R......Dearborn, Mich.
Seidl, F...........New York, N. Y.
Seidler, M. F........Harrison, N. J.
Seifert, R. W........Monsanto, Ill.
Seigle, W. R......New York, N. Y.
Seiple, J. W........Waterloo, Iowa
Seitz, D. C.........Cleveland, Ohio
Sekely, S..........Susquehanna, Pa.
Sekiguchi, Y..........Tokyo, Japan
Selim, J. D...........Chicago, Ill.
Selkinghaus, W. E....Raleigh, N. C.
Selkirk, W. M........Monessen, Pa.
Sellers, C., 3rd.....Philadelphia, Pa.
Sellers, W. M............Dallas, Tex.
Sellew, Welles H...New York, N. Y.
Sellew, Wm. Hamilton........ Ann Arbor, Mich.
Sellman, N. T......New York, N. Y.
Sells, W. D..........Lansdowne, Pa.
Selser, T. W......Los Angeles, Calif.
Selts, W. A.........Brooklyn, N. Y.
Seltzer, H. S.......Union City, N. J.
Seltzer, R. J.......Bakersfield, Calif.
Selvey, A. M.........Detroit, Mich.
Selvey, W. M..........London, Eng.
Selvidge, R. W.........Columbia, Mo.
Selving, H. T........Detroit, Mich.
Semel, E..........Philadelphia, Pa.

Semenetz, K. R......Torrance, Calif.
Semino, A. F..Mountain View, Calif.
Semple, D. M....Glasgow, Scotland
Sencebaugh, C. K....La Grange, Ill.
Senger, W. I..........Madison, Wis.
Sengstaken, J. H....New York, N. Y.
Senseman, W. B..Los Angeles, Calif.
Senter, C. A.........Brooklyn, N. Y.
Serrell, J. A.........Redlands, Calif.
Serrell, J. J..........Newark, N. J.
Serrell, P. V. H......Pasadena, Calif.
Service G.........Toronto, Ont., Can.
Sessions, F. L.........Cleveland, Ohio
Setchell, J. E.........Brooklyn, N. Y.
Setchell, J. S.........Brooklyn, N. Y.
Setchkin, N. P......New York, N. Y.
Seter, P. K.........Wauwatosa, Wis.
Sether, J. A.........Brooklyn, N. Y.
Seton, B. W.....Montreal, Que., Can.
Setzler, P. H........Cleveland, Ohio
Seutter, L.........Milwaukee, Wis.
Severns, W. H..........Urbana, Ill.
Severs, E. B........Philadelphia, Pa.
Severy, V. H........Glendale, Calif.
Sevilla, G. J...........Manila, P. I.
Seward, H. L.....New Haven, Conn.
Seward, R. B......New York, N. Y.
Sewell, H. R...........Boston, Mass.
Sewell, J. G. C.......Pittsburgh, Pa.
Sexton, S. B., 3rd.....Baltimore, Md.
Seybold, E..........Barberton, Ohio
Seyfarth, F.......Phillipsburg, N. J.
Seyfried, C. L.......Brooklyn, N. Y.
Seyler, G. A........Cincinnati, Ohio
Seymour, J. A.........Auburn, N. Y.
Shaal, L. F........Providence, R. I.
Shabsay, S........Toronto, Ont., Can.
Shade, N. R.....Los Angeles, Calif.
Shafer, A. C........Cincinnati, Ohio
Shafer, C., Jr......New York, N. Y.
Shaffer, J. C...........Toledo, Ohio
Shaffer, M. L............Akron, Ohio
Shaffer, M. W......Philadelphia, Pa.
Shaffer, T. G........Hartford, Conn.
Shaffner, C. R............Joliet, Ill.
Shakman, J. G..........Peoria, Ill.
Shallenberger, G. G...St. Paul, Minn.
Shank, J. M.........Columbus, Ohio
Shanks, G. L..........St. Louis, Mo.
Shannon, D. H........Detroit, Mich.
Shannon, F. P........Pottsville, Pa.
Shannon, J. R....N. Charleston, S. C.
Shannon, L. N......Birmingham, Ala.
Shanor, E. E............Sharon, Pa.
Shapiro, C.........Philadelphia, Pa.
Shapiro, E..............Dallas, Tex.
Sharma, O. N......Gulab-bari, India
Sharp, C. K..........Memphis, Tenn.
Sharp, H. M..........Buffalo, N. Y.
Sharp, J. C.....Salt Lake City, Utah
Sharp, R. D............Chester, Pa.
Sharp, R. E. B.....Philadelphia, Pa.
Sharpe, C. E..........Dayton, Ohio.
Sharpe, H. D......Providence, R. I.
Shattuck, C. H...Los Angeles, Calif.
Shaughness, T. B........Dallas, Tex.
Shaver, P. E............Chester, Pa.
Shaw, B. E.........Des Moines, Iowa
Shaw, B. F., II.....Wilmington, Del.
Shaw, D. E............E. Lynn, Mass.
Shaw, E. C...........Akron, Ohio
Shaw, H. G............Newark, N. J.
Shaw, H. W.......Charleston, W. Va.
Shaw, J. C..........Mercedes, Tex.
Shaw, J. H.........Wilmington, Del.
Shaw, L. E..........E. Orange, N. J.
Shaw, M. M...........Portland, Me.
Shaw, R., Jr........Waterbury, Conn.
Shaw, R. S...........Hartford, Conn.
Shaw, S. F..........San Antonio, Tex.
Shaw, W. C.....San Francisco, Calif.
Shaw, W. F..........Mercedes, Tex.
Shawk, H. A.........Piedmont, Calif.
Shea, A. L...........Camden, N. J.
Shea, F. X.Maracaibo, Venezuela, S. A.
Shea, J. B.............Derby, Conn.
Shea, J. R.............Kearny, N. J.
Sheaffer, E. F......New York, N. Y.
Sheard, T. R..........Cathay, N. D.
Shearer, D. R...Johnson City, Tenn.
Shearer, J. H...........Altoona, Pa.
Shearer, T. J..........Chicago, Ill.
Shearouse, J. D..........Atlanta, Ga.
Sheda, H. E...........Denver, Colo.
Sheda, R. M...........Denver, Colo.
Shedd, F. R........Charleston, W. Va.
Shedd, W. R...........Rockford, Ill.
Sheehan, E. W..Chicago Heights, Ill.
Sheehan, J. A......E. Walpole, Mass.
Sheehan, W. M.......Eddystone, Pa.
Sheelor, A. P...........DeKalb, Ill.
Shelden, W. L...Toronto, Ont., Can.
Sheldon, A. N.......Providence, R. I.
Sheldon, L. A....Schenectady, N. Y.
Sheldon, M. B............Easton, Pa.
Sheldon, O. C.......New York, N. Y.
Sheldon, T. C.......Fitchburg, Mass.

Sheldon, W. D.......Galt, Ont., Can.
Shelton, C. L.......Philadelphia, Pa.
Shelton, N. T......New York, N. Y.
Shelton, R. M.........Cleveland, Ohio
Shelton, W. A.....Los Angeles, Calif.
Shepard, F. E..........Denver, Colo.
Shepard, F. J., Jr..W. Newton, Mass.
Shepard, F. S.......New York, N. Y.
Shepard, G. H....W. Lafayette, Ind.
Shepard, G. R....Niagara Falls, N. Y.
Shepard, R. H......New York, N. Y.
Shepard, S..............Paris, France
Sheperdson, J. W....Worcester, Mass.
Shepherd, R. B. H...Memphis, Tenn.
Shepherd, W. G....Williamsport, Pa.
Shepler, P. R.......Cleveland, Ohio
Shequine, E. R.........Boston, Mass.
Sherban, D. V......New York, N. Y.
Shereff, B.............Butler, N. J.
Sherman, C. N.......Syracuse, N. Y.
Sherman, D. C..........Chicago, Ill.
Sherman, G. S......New York, N. Y.
Sherman, J. F......Somerville, Mass.
Sherman, K. M......Honolulu, T. H.
Sherman, R. A......Columbus, Ohio
Sherman, V. L.........Chicago, Ill.
Sherman, W. L.......Brooklyn, N. Y.
Sherman, W. P................ Jackson Heights, L. I., N. Y.
Sherman, W. S..Oklahoma City, Okla.
Sherman, W. T......Paulsboro, N. J.
Sherron, J...........Norwalk, Conn.
Sherwood, E. L......New York, N. Y.
Sherwood, H. L.......Oakland, Calif.
Sherwood, M. W........Chicago, Ill.
Shetland, D. V.........Solvay, N. Y.
Shetler, A. E...........Copley, Ohio
Shettel, W. R....Los Angeles, Calif.
Shewbridge, W. H..Waterbury, Conn.
Shie, C. H............Painesville, Ohio
Shields, R. I....Redwood City, Calif.
Shields, W. H...........Tulsa, Okla.
Shiland, F. H...........Chester, Pa.
Shima, Y.............Tokyo, Japan
Shimer, A. A.......Wilmington, Del.
Shimer, J. M............Dallas, Tex.
Shinkle, V. G.......New York, N. Y.
Shipley, G. B........Pittsburgh, Pa.
Shipley, K. R.....Toronto, Ont., Can.
Shipman, W. H.......Barberton, Ohio
Shires, F..........Wellsville, N. Y.
Shirk, W. F.............Sharon, Pa.
Shirley, H. J........Cincinnati, Ohio
Shirley, J. G........N. Adams, Mass.
Shirley, R..........Springfield, Mass.
Shirrell, C. P.....Schenectady, N. Y.
Shirtley, S. L.........Sydney, Aust.
Shockley, H. W.....Wilmington, Del.
Shodron, J. G....Fort Atkinson, Wis.
Shoemaker, F. R....Springfield, Mass.
Shoemaker, G. T....Kansas City, Mo.
Shoemaker, O. H., Jr..Barberton, Ohio
Shoemaker, P. M...New Haven, Conn.
Shoemaker, R. W...Waterbury, Conn.
Shoemaker, W. T......Meadville, Pa.
Shonnard, H. W.....Montclair, N. J.
Shook, G. W.........Ft. Peck, Mont.
Shoop, C. F......Minneapolis, Minn.
Shoor, S............Brooklyn, N. Y.
Shorey, J. A.......New York, N. Y.
Short, B. E.............Austin, Tex.
Short, H. M..........Auburn, N. Y.
Short, M. K............Moline, Ill.
Short, R. M.............Sardis, Miss.
Shoudy, W. A.......New York, N. Y.
Shouvlin, P. J......Springfield, Ohio
Shovar, C. B......Bremerton, Wash.
Showers, C. G...Sandwich, Ont., Can.
Shreeve, C. A., Jr.....Baltimore, Md.
Shreve, E. O......Schenectady, N. Y.
Shriver, H. T...........Benson, Md.
Shuart, A. C........Evansville, Ind.
Shuckart, J. B...San Francisco, Calif.
Shuff, E. L.............Atlanta, Ga.
Shultis, A. E........New York, N. Y.
Shultz, E. O......Minneapolis, Minn.
Shultz, J. A.........Montclair, N. J.
Shultz, R. H.........Richmond, Va.
Shuman, L. E.........Balboa, C. Z.
Shumate, F. D......New York, N. Y.
Shumowsky, S. A....New York, N. Y.
Shute, H. R.......Philadelphia, Pa.
Shutko, F. W.........Detroit, Mich.
Sibert, M. L.....Chattanooga, Tenn.
Sibley, B. E.......Ponca City, Okla.
Sibley, E. W...........Boston, Mass.
Sibley, F. H.............Reno, Nev.
Sibley, R............Berkeley, Calif.
Sibole, B. P.............Tulsa, Okla.
Sibson, H. E.......Bala-Cynwyd, Pa.
Sibson, W. A.........Paulsboro, N. J.
Sibson, W. W., Jr..Philadelphia, Pa.
Sicka, L. T.........Bonne Terre, Mo.
Sickles, E. C........New York, N. Y.
Sidler, E. H......Zurich, Switzerland
Sidler, P. R........New York, N. Y.
Sidmore, B., Jr.....St. Joseph, Mich.

Sidney, W. E.........Pittsburgh, Pa.
Sidserf, E. H..........Newark, N. J.
Sieber, W. J.......Jersey City, N. J.
Siebert, V. W.........Laramie, Wyo.
Siedle, A. D..........Canton, Ohio
Siefert, G. C........New York, N. Y.
Sieger, E. K........New York, N. Y.
Siegerist, W..........St. Louis, Mo.
Siegesmund, J. C...Indianapolis, Ind.
Siekierka, F..........Taunton, Mass.
Siemon, W. A......Youngstown, Ohio
Siess, E............New York, N. Y.
Sietsma, S. J.........Lafayette, Ind.
Sievers, E. J. J.....Hoboken, N. J.
Sieweck, C. A.......New York, N. Y.
Sigmon, A. C..........Dayton, Ohio
Signarowitz, F. J. San Francisco, Calif.
Signorelli, A..........Newark, N. J.
Sigrist, H....Sao Paulo, Brazil, S. A.
Sigworth, R. Y.....State College, Pa.
Sihler, J. H......Washington, D. C.
Sikosek, F. J......Coytesville, N. J.
Silber, V...........Brooklyn, N. Y.
Silberger, M. E............York, Pa.
Siler, L. N.........Wilmington, Del.
Sillcox, L. K.......Watertown, N. Y.
Silver, M...Southampton, L. I., N. Y.
Simanek, C. J...........Racine Wis.
Simeon, C. J.......Providence, R. I.
Simmering, S. L......Boulder, Colo.
Simon, A...........Milwaukee, Wis.
Simon, S...........Nashville, Tenn.
Simon, W.........Emeryville, Calif.
Simon, W. A........Milwaukee, Wis.
Simons, L..........New York, N. Y.
Simonson, H. E....Bartlesville, Okla.
Simpson, A. M...............
Jackson Heights, L. I., N. Y.
Simpson, C. C., Jr...New York, N. Y.
Simpson, F. C.........Boston, Mass.
Simpson, G. B. Vancouver, B. C., Can.
Simpson, G. R......Washington, D. C.
Simpson, R. H.....Jersey City, N. J.
Simpson, R. J. O..........Athol, Mass.
Simpson, T. F.....Los Angeles, Calif.
Simpson, W. K.....Waterbury, Conn.
Simson, J........Los Angeles, Calif.
Sinclair, L. P., Jr...Waterbury, Conn.
Sinclair, R. McH...Noranda, Que., Can.
Singer, F. L.........New York, N. Y.
Singer, Sidney C...Los Angeles, Calif.
Singer, Sidney C., Jr..Glendale, Calif.
Singh, I...............Lahore, India
Singh, J...........Chheharta, India
Singh, N............Phillaur, India
Sinha, J..........Jamshedpur, India
Sintz, C..............Detroit, Mich.
Sir, W. W.............Chicago, Ill.
Siroky, E............St. Louis, Mo.
Sirrine, J. E........Greenville, S. C.
Sisson, C. H........Cincinnati, Ohio
Sizer, H. S.........Providence, R. I.
Sizer, W. D..........Harrison, N. J.
Sjorgren, C. A..........Lincoln, Neb.
Skabo, H. H.......Indianapolis, Ind.
Skagen, S............Pittsburgh, Pa.
Skaggs, H. C., Jr. Montgomery, W. Va.
Skelly, J. F.......Ogdensburg, N. Y.
Skilton, H. I..........Havana, Cuba
Skinner, A. D..............Erie, Pa.
Skinner, H. N........Yonkers, N. Y.
Skinner, J. A........Holyoke, Mass.
Skinner, J. C.......Philadelphia, Pa.
Skinner, J. D......Bridgeport, Conn.
Skinner, O. H......Indianapolis, Ind.
Skinner, S. E.........Detroit, Mich.
Sklovsky, M............Moline, Ill.
Skog, L...............Chicago, Ill.
Skoglund, V. J....New Haven, Conn.
Skortz, A. C............Scheller, Ill.
Skrotzki, B. G. A....Brooklyn, N. Y.
Skule, J. C. J. Copenhagen, Denmark
Slade, F. L...........St. Louis, Mo.
Slader, W............Acworth, N. H.
Slater, F......Vancouver, B. C., Can.
Slaughter, C. H..Grand Rapids, Mich.
Slauson, H. W......New York, N. Y.
Slavenak, A. J., Jr....Trenton, N. J.
Slaymaker, P. K.......Lincoln, Neb.
Slaymaker, R. R.........Dallas, Tex.
Slayton, E. T.......Rochester, N. Y.
Slechta, E....Prague, Czechoslovakia
Sledge, B. J..........Canton, N. C.
Slee, N. S..........New York, N. Y.
Sleeman, E. C.......Dearborn, Mich.
Slichter, W. I.......New York, N. Y.
Slifka, M...........New York, N. Y.
Slingman, T. D., Jr..New York, N. Y.
Sloan, W. A........Philadelphia, Pa.
Sloane, R. G........Elizabeth, N. J.
Sloat, B. C.........New York, N. Y.
Slocombe, B.........Lynchburg, Va.
Sloman, R. A....Turners Falls, Mass.
Slomer, W. F.........Detroit, Mich.
Slusher, H. J., Jr......Dayton, Ohio
Sluss, A. H..........Lawrence, Kan.

Smack, J. C........New York, N. Y.
Small, L.............Detroit, Mich.
Smallwood, J. C......Baltimore, Md.
Smart, R. A........Philadelphia, Pa.
Smeal, M. W...........Akron, Ohio
Smellie, D. G..........Canton, Ohio
Smeltzer, A. B......Vandergrift, Pa.
Smend, W. C........Westwood, N. J.
Smethurst, J. R......Holyoke, Mass.
Smiley, C. B........Pittsburgh, Pa.
Smiley, E..........Philadelphia, Pa.
Smith, A. C.........New York, N. Y.
Smith, A. D., Jr.......Louisville, Ky.
Smith, A. E............Chicago, Ill.
Smith, Allen, E..Palisades Park, N. J.
Smith, A. K..........W. Orange, N. J.
Smith, A. L........Worcester, Mass.
Smith, A. P.........New York, N. Y.
Smith, A. R......Schenectady, N. Y.
Smith, A. W............Ithaca, N. Y.
Smith, B. C.......Jersey City, N. J.
Smith, B. E................York, Pa.
Smith, B. O.........Plainfield, N. J.
Smith, C..............Boston, Mass.
Smith, C. A.............Mexico, Mo.
Smith, C. D.........Lancaster, Ohio
Smith, C. E..........Brooklyn, N. Y.
Smith, C. F.........Waltham, Mass.
Smith, C. H.........Alhambra, Calif.
Smith, C. R..........Milwaukee, Wis.
Smith, D. A.........Brooklyn, N. Y.
Smith, Eastman.........Newark, N. J.
Smith, Elmer..........Boston, Mass.
Smith, Earl B........New York, N. Y.
Smith, Edric Brooks. New York, N. Y.
Smith, E. Dillon.....New York, N. Y.
Smith, Edwin D........Dayton, Ohio
Smith, Earle E.......Pittsburgh, Pa.
Smith, Elliott E.......Scranton, Pa.
Smith, E. G......Glens Falls, N. Y.
Smith, E. H..........Worcester, Mass.
Smith, E. J........Wilkes-Barre, Pa.
Smith, E. Lovell....Springfield, Mass.
Smith, Elwyn L........Syracuse, N. Y.
Smith, E. R......Seneca Falls, N. Y.
Smith, E. S., Jr.......Brooklyn, N. Y.
Smith, F. A............Altoona, Pa.
Smith, F. B.....San Francisco, Calif.
Smith, F. E.........Wilmington, Del.
Smith, F. H.........New York, N. Y.
Smith, F. W.........New York, N. Y.
Smith, Geo. Hillier............
Montreal, Que., Can.
Smith, Geo. Hoffman. Jacksonville, Fla.
Smith, Geo. Lee......Cleveland, Ohio
Smith, Gerard L..........York, Pa.
Smith, G. W..........Pittsburgh, Pa.
Smith, Harold A...Sugar Creek, Mo.
Smith, Harry A.....New York, N. Y.
Smith, Harold Baker. Southport, N. C.
Smith, Henry Bassett. Westville, N. J.
Smith, H. C., Jr........Chicago, Ill.
Smith, H. G......Old Hickory, Tenn.
Smith, Harry J...San Francisco, Calif.
Smith, Herbert J....Greenfield, Mass.
Smith, Harold L.........Buffalo, N. Y.
Smith, Harry L.......Biddeford, Me.
Smith, H. Le H.......Brooklyn, N. Y.
Smith, H. N...........Buffalo, N. Y.
Smith, H. P...Windsor Locks, Conn.
Smith, H. Raymond..New York, N. Y.
Smith, Henry R.........Everett, Mass.
Smith, H. S........New York, N. Y.
Smith, H. W.......Youngstown, Ohio
Smith, J. C.....San Francisco, Calif.
Smith, J. D..........Pottsville, Pa.
Smith, J F D......Philadelphia, Pa.
Smith, J. H...........Pittsburgh, Pa.
Smith, J. J..........New York, N. Y.
Smith, J. K....Monument, New Mex.
Smith, J. M............Beloit, Wis.
Smith, J. R..........Burnham, Pa.
Smith, J. S...........Jeannette, Pa.
Smith, J. U.........Berkeley, Calif.
Smith, K. V..........Oakland, Calif.
Smith, L. C.........Charlotte, N. C.
Smith, L. G..........Baltimore, Md.
Smith, LeR. I.........Buffalo, N. Y.
Smith, L. L.......Minneapolis, Minn.
Smith, M. B...........Detroit, Mich.
Smith, M. E...............Erie, Pa.
Smith, M. H.......Wilmington, Del.
Smith, M. M.............Paris, France
Smith, M. S..........Richmond, Va.
Smith, N. L.........Philadelphia, Pa.
Smith, Peter A......E. Orange, N. J.
Smith, Prescott A....Hartford, Conn.
Smith, P. F., Jr....Philadelphia, Pa.
Smith, P. H..........Bridgeton, N. J.
Smith, P. M.......Wilmington, Del.
Smith, R. B.........Swarthmore, Pa.
Smith, R. C.........New York, N. Y.
Smith, R. E...Long Island City, N. Y.
Smith, R. H...............Kent, Ohio
Smith, R. K..........Milwaukee, Wis.
Smith, R. L........Cincinnati, Ohio

Smith, Randolph M............
Long Island City, N. Y.
Smith, Robt. M....Youngstown, Ohio
Smith, R. R.........Cleveland, Ohio
Smith, Ronald R........Beloit, Wis.
Smith, Robt. Warren..........
Springfield, Ohio
Smith, Robt. Wm...Wyandotte, Mich.
Smith, S. H.........Cleveland, Ohio
Smith, T. C........Glen Rock, N. J.
Smith, T. E............Atlanta, Ga.
Smith, T. H.........Brooklyn, N. Y.
Smith, T. J............Chicago, Ill.
Smith, V..........Melbourne, Aust.
Smith, V. J.........Cleveland, Ohio
Smith, V. W...........Muncie, Ind.
Smith, Walter.........Chicago, Ill.
Smith, Walter......Philadelphia, Pa.
Smith, W. A...........Buffalo, N. Y.
Smith, W. C......Indianapolis, Ind.
Smith, Wayne Everett..........
New York, N. Y.
Smith, Wm. Earhart..Honolulu, T. H.
Smith, W. H.........Detroit, Mich.
Smith, W. M.......New York, N. Y.
Smith, W. P..........Dayton, Ohio
Smith, W. R.......Philadelphia, Pa.
Smith, Y. C...........Detroit, Mich.
Smithe, F. L.......New York, N. Y.
Smithson, H. R........Cheyney, Pa.
Smolderen, F. V..W. New York, N. J.
Smoot, L. E......Washington, D. C.
Smulders, F., Jr. Mountain Lakes, N. J.
Smyser, E. P....New Wilmington, Pa.
Snaith, W.......Montreal, Que., Can.
Snashall, N. W.........Chicago, Ill.
Snavely, A. B..........Hershey, Pa.
Sneath, W. H.......New York, N. Y.
Snedden, W. T.........Chicago, Ill.
Sneden, H. J.......Indianapolis, Ind.
Snelling, H. H....Washington, D. C.
Snider, A. M....Waterloo, Ont., Can.
Snider, C. A........New York, N. Y.
Snider, L. A...........Chicago, Ill.
Sniffen, W. H.........Norwalk, Conn.
Snow, B. H...........Boston, Mass.
Snow, W. S.........Worcester, Mass.
Snowden, H. J..........Chicago, Ill.
Snyder, G. T.......Centerville, Mass.
Snyder, H. E..........Newark, N. J.
Snyder, Harry Wm. Little Falls, N. Y.
Snyder, Herbert W.......Lima, Ohio
Snyder, J. A.........Pittsburgh, Pa.
Snyder, J. H........Rochester, N. Y.
Snyder, L. F.......Philadelphia, Pa.
Snyder, L. L......Los Angeles, Calif.
Snyder, M. F.......Bottineau, N. D.
Snyder, S. M., Jr.....Barberton, Ohio
Snyder, W. E......Philadelphia, Pa.
Soars, J. W.........Pittsburgh, Pa.
Soderberg, C. R.....Philadelphia, Pa.
Soderberg, E. W....Watertown, Conn.
Soderstrom, O. A..Minneapolis, Minn.
Solberg, H. L.....W. Lafayette, Ind.
Soldan, H. M..........Leonia, N. J.
Soling, S. P..........Myerstown, Pa.
Soller, A.........Michigan City, Ind.
Solomon, E. J...........Butte, Mont.
Solomon, G. R...........Troy, N. Y.
Solot, K...........Philadelphia, Pa.
Solov, A............Brooklyn, N. Y.
Somers, D. LeR....Waterbury, Conn.
Somers, H. A., Jr...Huntington, Ind.
Somers, J. C.......New York, N. Y.
Somers, W. E........New York, N. Y.
Somervell, P. A.....Philadelphia, Pa.
Somerville, G. N......Oakland, Calif.
Sommarstrom, C. E....Oakland, Calif.
Sommer, P. L., Jr...Tarrytown, N. Y.
Sommers, W. J..........Fremont, Neb.
Sommerville, D. P....Pittsburgh, Pa.
Somogyi, C. E......Cincinnati, Ohio
Sonderman, G.........New York, N. Y.
Sonderman, H. C....Rochester, N. Y.
Sonn, F. W..........Pottstown, Pa.
Sonn, G. P.........Mercerville, N. J.
Sontag, H. P..........Auburn, N. Y.
Sookasian, G. H....Philadelphia, Pa.
Sooy, W. E........Middletown, Ohio
Soper, H. F.......New York, N. Y.
Sorensen, H. A.......Hartford, Conn.
Sorensen, L. C.......Lockland, Ohio
Sorenson, A. E......Princeton, N. J.
Soroka, W. W.......Cambridge, Mass.
Soteriou, J. G.........W. Allis, Wis.
Souba, W. H......Minneapolis, Minn.
Soucek, J. L............Moline, Ill.
Soulen, P. J.........Milwaukee, Wis.
Soulis, H. A..........Newark, N. J.
Soulis, W. T.............Easton, Pa.
Sounitza, W...........Houston, Tex.
Southack, T. W....Greenwich, Conn.
Southern, G. W.........Sheffield, Eng.
Southern, H..........Sheffield, Eng.
Southwick, B. H......E. Lynn, Mass.
Sowden, P. T.....Canajoharie, N. Y.

Sowers, D. W.........Buffalo, N. Y.
Spackman, G. D.....Coatesville, Pa.
Spahn, C. F...Hempstead, L. I., N. Y.
Spahr, R. H..............Flint, Mich.
Spain, R. W........Terre Haute, Ind.
Spalding, F. W.....Cincinnati, Ohio
Spangler, J. I.............York, Pa.
Spangler, S. F......New York, N. Y.
Sparks, A. F.........Springfield, Ohio
Sparks, A. C...........London, Eng.
Sparks, C. H.........Weybridge, Eng.
Sparling, R. C....Los Angeles, Calif.
Sparrow, S. W.........S. Bend, Ind.
Spaulding, E. R.....Worcester, Mass.
Spaulding, H. S.....Pasadena, Calif.
Spaunburg, H. L.....Hartford, Conn.
Spear, F. H..........Burlington, Vt.
Spear, L. Y...........Groton, Conn.
Spear, M. H...Flushing, L. I., N. Y.
Spears, J. B........Chickasha, Okla.
Spector, B..........New York, N. Y.
Speed, W. S.........Louisville, Ky.
Speer, G. R...........Hoboken, N. J.
Speer, J. R...........Swissvale, Pa.
Speer, K. T............Salem, N. C.
Speight, H.........New York, N. Y.
Speller, F. N........Pittsburgh, Pa.
Spellman, C. B.....Philadelphia, Pa.
Spence, H. de L......Cleveland, Ohio
Spence, L. D.......Providence, R. I.
Spence, R. A.........Belmont, Mass.
Spencer, Alex. Chas............
London, Ont., Can.
Spencer, Alfred Chas., Jr.......
S. Orange, N. J.
Spencer, B. H......New York, N. Y.
Spencer, C. G......New York, N. Y.
Spencer, C. W.......E. Orange, N. J.
Spencer, F. A..........Maurer, N. J.
Spencer, Frank C....Westfield, N. J.
Spencer, Frank C., Jr. Westfield, N. J.
Spencer, H. W.........London, Eng.
Spencer, R. L..........Newark, Del.
Spencer, V...........Lancaster, Pa.
Spengler, R. A.......Cleveland, Ohio
Sperling, G. E........Pittsburgh, Pa.
Spero, C. W........New York, N. Y.
Sperry, C. E........New York, N. Y.
Sperry, E. A., Jr....Brooklyn, N. Y.
Sperry, E. G.........Brooklyn, N. Y.
Sperry, R. S.......Waterbury, Conn.
Sperry, S. E., Jr..............
Great Neck, L. I., N. Y.
Sperry, S. M...........Reading, Pa.
Sperzel, J. M.......New York, N. Y.
Spicacci, A. R.........Bristol, Conn.
Spicer, C. W...........Toledo, Ohio
Spicer, G. T., Jr...Providence, R. I.
Spiehler, C. H......Cincinnati, Ohio
Spies, F. L......Gilmore City, Iowa.
Spiesz, C. P.....Williamsville, N. Y.
Spieth, B..............Racine, Wis.
Spievak, J...........Brooklyn, N. Y.
Spillman, H.........Muskegon, Mich.
Spining, W. P......Cincinnati, Ohio.
Spiro, I. J..............Chicago, Ill.
Spiro, W. J.......Dobbs Ferry, N. Y.
Spitzglass, A. F.........Chicago, Ill.
Spivak, B. L........New York, N. Y.
Spoerr, F. F......Jamaica, L. I., N. Y.
Spofford, H. H. R............
Wellesley Hills, Mass.
Spofford, W. A....Bloomfield, N. J.
Spooner, C. W., Jr..Ann Arbor, Mich.
Sporleder, E., Jr......St. Louis, Mo.
Sporn, P...........New York, N. Y.
Spotton, A. K.......Galt, Ont., Can.
Spotts, H. J..........Duluth, Minn.
Sprado, R.........Los Angeles, Calif.
Sprague, B. O........Savannah, Ga.
Sprague, D..........New York, N. Y.
Sprague, H. F......Steubenville, Ohio
Sprague, O. V......Rochester, N. Y.
Sprague, P. T.....Michigan City, Ind.
Sprague, R............Peapack, N. J.
Sprague, R. W........Conneaut, Ohio
Sprague, T. S......New York, N. Y.
Sprague, W. W........Savannah, Ga.
Spratt, H. P...........London, Eng.
Sprenkle, R. E.......Cleveland, Ohio
Springe, W.........Kansas City, Mo.
Springer, E. K.....Los Nietos, Calif.
Springer, R. S..San Francisco, Calif.
Sproat, J. R...........Oakmont, Pa.
Sprong, S. D.......New York, N. Y.
Spross, H. M.....Poughkeepsie, N. Y.
Spruitenburg, M. J............
New Brunswick, N. J.
Spurgeon, J. H........Detroit, Mich.
Spurling, O. C......New York, N. Y.
Squires, R..........Philadelphia, Pa.
Srogi, L..............Elmira, N. Y.
Staber, G. I.......Williamsport, Pa.
Stack, D. P.........Brooklyn, N. Y.
Stackhouse, H. L..Battle Creek, Mich.
Stacy, P. A., Jr.....Pasadena, Calif.
Stacy, S. C.........Rochester, N. Y.

Stadler, J......Montreal, Que., Can.
Stadtherr, N. G.....Leominster, Mass.
Staege, S. A.......Middletown, Ohio
Stafford, J. W.......New York, N. Y.
Stafford, P. H...........Essex, N. Y.
Stafford, P. W.......Middleboro, Mass.
Stafford, R. G........Norristown, Pa.
Stafford, W. H....Charleston, W. Va.
Stahl, E. C. M.......Brooklyn, N. Y.
Stahl, F. E........Tonawanda, N. Y.
Stahl, J. F..........Cleveland, Ohio
Stahl, N.............Allentown, Pa.
Staiger, W.........New York, N. Y.
Stalder, L. R.......Kansas City, Mo.
Staley, P. A........Springfield, Ohio
Stalker, E. A.......Ann Arbor, Mich.
Stall, E. R..........Greenville, S. C.
Stamer, F. R.........New York, N. Y.
Stamm, J. D.......Youngstown, Ohio
Stamp, J. W. H..New Brunswick, N. J.
Stanbrook, R. C...Rogers City, Mich.
Stancliff, A. D......New Orleans, La.
Standish, E. K........Holyoke, Mass.
Standley, A. H.....Downingtown, Pa.
Stanek, J. H........Milwaukee, Wis.
Stanford, R. F.........Lombard, Ill.
Stangeland, O. I........Chicago, Ill.
Stangland, B. F.......Kendall, N. Y.
Stangland, R. S......New York, N. Y.
Stanhope, H. W. P..New York, N. Y.
Staniar, W.........Wilmington, Del.
Stanley, A. W....New Britain, Conn.
Stanley, C. Maxwell..Muscatine, Iowa
Stanley, Carroll M.....Summit, N. J.
Stanley, R.........Maribyrong, Aust.
Stansfield, F. H....Bridgeport, Conn.
Stansfield, W. A....Lake Monroe, Fla.
Stanton, A. L.......St. Austell, Eng.
Stanton, R. E..........Marshall, Ill.
Stanwick, C. A......S. Orange, N. J.
Stanyan, S. W..........Lynn, Mass.
Stapfer, R. D........Irvington, N. J.
Staple, S. J..............Lead, S. D.
Staples, C. W........Paulsboro, N. J.
Staples, E. I....San Francisco, Calif.
Staples, F. C........Brooklyn, N. Y.
Staples, H. A........New York, N. Y.
Stappert, O. E..................
Queens Village, L. I., N. Y.
Starbuck, G. F.....N. Billerica, Mass.
Starbuck, R. A....Chestertown, N. Y.
Stark, A. W........New York, N. Y.
Stark, J. E.............Chicago, Ill.
Stark, LaR. H......Milwaukee, Wis.
Stark, W. E.........Cleveland, Ohio
Starke, O. A., Jr....Ludington, Mich.
Starke, W. W....Orchard Park, N. Y.
Starkey, D. W...........Palatka, Fla.
Starkweather, J. D.....Detroit, Mich.
Starkweather, W. G....Boston, Mass.
Starr, C. J..............Urbana, Ill.
Starr, M. O........New Haven, Conn.
Staub, M. H........New York, N. Y.
Staude, E. G.........St. Paul, Minn.
Stauffer, R. D......Cambridge, Mass.
Staver, E. F.........Brooklyn, N. Y.
Stead, F. A.........New York, N. Y.
Stearns, E. J., Jr...New Orleans, La.
Stearns, F. A..........Boston, Mass.
Stearns, K. T..........Boston, Mass.
Stearns, T. B..........Denver, Colo.
Stebbins, T.........New York, N. Y.
Steck, R. C........Mt. Vernon, N. Y.
Steckler, N..........Cincinnati, Ohio
Steczynski, M. E........Chicago, Ill.
Steel, J............Los Mochis, Mex.
Steele, M. G..........Baltimore, Md.
Steele, R. W......Schenectady, N. Y.
Steele, S.........Christchurch, N. Z.
Steele, W. D..........Des Plaines, Ill.
Steen, A. B., Jr........Houston, Tex.
Steen, H.......Woodside, L. I., N. Y.
Steen, S.............Concrete, Wash.
Steen-Johnsen, H....Philadelphia, Pa.
Steer, D. E........Waterbury, Conn.
Stefanac, J. B......San Diego, Calif.
Stefano, N...........Endicott, N. Y.
Steffa, H. I.............Chicago, Ill.
Steffan, C. H...Glendale, L. I., N. Y.
Steffani, E. C......Santa Cruz, Calif.
Steffey, J. G., Jr..Sparrows Point, Md.
Stegmann, G. H....Mt. Vernon, N. Y.
Steil, M. J........Cold Spring, Minn.
Steilen, L. J.........Brooklyn, N. Y.
Stein, C. P.............Bristol, Conn.
Stein, F. W............Dayton, Ohio
Stein, P. J...........Barberton, Ohio
Steinbach, E. S.........Boston, Mass.
Steinbeck, C. E..San Francisco, Calif.
Steinberg, H........New York, N. Y.
Steinberg, H. G........Brooklyn, N. Y.
Steinberg, L.........New York, N. Y.
Steiner, O..........Rochester, N. Y.
Steiner, W. A..........Fostoria, Ohio
Steinke, O. F.....New Britain, Conn.
Steinman, G.........Brooklyn, N. Y.
Steinmeyer, J. W.......Berwick, Pa.
Steins, C. K........Wilmington, Del.

Stellwagen, R. H......Detroit, Mich.
Stelz, F. F........Binghamton, N. Y.
Stem, F. B.........Philadelphia, Pa.
Stengren, J. S......New York, N. Y.
Stenson, C. J........New York, N. Y.
Stenstrom, A. E........Rockford, Ill.
Stentz, F. W............Gary, Ind.
Stepan, T. E........Vicksburg, Miss.
Stepanoff, A. J.......Berkeley, Calif.
Stephan, W. G.......Cleveland, Ohio
Stephan, W. N......Philadelphia, Pa.
Stephens, E. C.......Cleveland, Ohio
Stephens, E. L.....Port Arthur, Tex.
Stephens, J. H......Ann Arbor, Mich.
Stephensen, F..Kings Park, L. I., N. Y.
Stephenson, A. M......Raleigh, N. C.
Stephenson, J..St. Welland, Ont., Can.
Stephenson, P. A.......Winnetka, Ill.
Stephenson, T. I........Alcoa, Tenn.
Sterling, C. H........Detroit, Mich.
Sterling, J. C....Newport News, Va.
Stern, A. C........New York, N. Y.
Stern, B.............Detroit, Mich.
Stern, I.............Brooklyn, N. Y.
Stern, J. H..Farmingdale, L. I., N. Y.
Sternal, N. J.........St. Paul, Minn.
Sternberg, E. R.....Milwaukee, Wis.
Sterner, D. S...........Dayton, Ohio
Stertzbach, H. W.....Columbus, Ohio
Stetson, G. A.........New York, N. Y.
Stetson, G. W..........Boston, Mass.
Stetson, R. W.........Meriden, Conn.
Steur, W. R.............Chicago, Ill.
Stevens, A. H...........Clinton, Conn.
Stevens, B. D...........Chicago, Ill.
Stevens, C. A.....Sand Springs, Okla.
Stevens, C. C...........Bristol, Conn.
Stevens, G. D.....Hartford City, Ind.
Stevens, G. E....New Rochelle, N. Y.
Stevens, G. W...........Dallas, Tex.
Stevens, H. E.............Troy, N. Y.
Stevens, H. W..Cumberland Mills, Me.
Stevens, J. E.........New York, N. Y.
Stevens, L. W.......Hartford, Conn.
Stevens, W. J.......Philadelphia, Pa.
Stevens, W. O.........Seattle, Wash.
Stevens, W. R.........Baltimore, Md.
Stevenson, A. R., Jr............
Schenectady, N. Y.
Stevenson, C. H..Santa Monica, Calif.
Stevenson, R. W..San Francisco, Calif.
Stevenson, W. N.........Chicago, Ill.
Steward, R. W......Little Rock, Ark.
Stewardson, E. E........Akron, Ohio
Stewart, A. A.......Fall River, Mass.
Stewart, B. C..........Detroit, Mich.
Stewart, C. D.......Wilmerding, Pa.
Stewart, C. R..........Boston, Mass.
Stewart, D. W......New Orleans, La.
Stewart, E. A......E. Orange, N. J.
Stewart, F. C......State College, Pa.
Stewart, F. Y.......New York, N. Y.
Stewart, G. G............Donora, Pa.
Stewart, H. P.........Oakland, Calif.
Stewart, Jas. A.......Brooklyn, N. Y.
Stewart, John A......Brooklyn, N. Y.
Stewart, J. G.........Camden, N. J.
Stewart, J. P.........Paulsboro, N. J.
Stewart, J. T........Lake Forest, Ill.
Stewart, M. G.........Shreveport, La.
Stewart, N. H.........Caldwell, N. J.
Stewart, N. L.........Garfield, Utah
Stewart, P. M.........Wilmington, Del.
Stewart, R. A...Winnipeg, Man., Can.
Stewart, R. E.......Hawthorne, N. J.
Stewart, R. T.........Pittsburgh, Pa.
Stewart, S. L., II.....Cleveland, Ohio
Stewart, S. W.......New York, N. Y.
Stewart, T. O.......New York, N. Y.
Stewart, W. B.....Washington, D. C.
Stewart, W. D..........Boston, Mass.
Stewart, Wm. Fraser...St. Louis, Mo.
Stewart, Wm. Fred.......Tulsa, Okla.
Stickley, P. E.........Massena, N. Y.
Stiefel, R. C.......Ellwood City, Pa.
Stiehl, H. M.........New York, N. Y.
Stienmier, H....La Madera, New Mex.
Stigen, R.......San Francisco, Calif.
Stiles, A. M...........St. Louis, Mo.
Stiles, L. S...........Brooklyn, N. Y.
Still, W. B..........Knoxville, Tenn.
Stillman, A. F..........Aldene, N. J.
Stillman, R. B..........Bradford, Pa.
Stillman, T. B.......New York, N. Y.
Stillwell, A. W........Wichita, Kan.
Stillwell, J. E...........Dallas, Tex.
Stine, S. S..............Lester, Pa.
Stinson, K. W........Columbus, Ohio
Stinson, L. S..........Pittsburgh, Pa.
Stires, W. H......High Bridge, N. J.
Stith, R. L..............Seattle, Wash.
Stitt, A. B.........New York, N. Y.
Stitt, W. T.........Brownsville, Tex.
Stivers, F. A...........Tulsa, Okla.
Stix, L. O..........New York, N. Y.
Stock, A. J..........Cleveland, Ohio
Stockel, F. C..Copenhagen, Denmark
Stockham, R.....Pedro Miguel, C. Z.

Stockwell, R. C........Buffalo, N. Y.
Stoddard, C. J........Boston, Mass.
Stoddard, E.....San Francisco, Calif.
Stoecker, O. C..........Butler, N. J.
Stoeltzing, H. E.....Brooklyn, N. Y.
Stoelzer, W. H......Brooklyn, N. Y.
Stoessel, R. F.......Milwaukee, Wis.
Stoever, A. C......Granite City, Ill.
Stoever, H. J.....W. Lafayette, Ind.
Stoker, L. P.....San Francisco, Calif.
Stolberg, E. C.........New York, N. Y.
Stoll, C. G.........New York, N. Y.
Stoll, J., Jr......S. Norwalk, Conn.
Stolz, P. L.........Kansas City, Mo.
Stolzenburg, F. O....Sheboygan, Wis.
Stone, B. L.........Torrance, Calif.
Stone, C. A.........New York, N. Y.
Stone, C. W........Schenectady, N. Y.
Stone, E. W.....Longmeadow, Mass.
Stone, H. L..........Evansville, Ind.
Stone, J. F...........Columbus, Ohio
Stone, J. L............Chicago, Ill.
Stone, J. R...Ft. Leavenworth, Kan.
Stone, L..............New York, N. Y.
Stone, M.............Pittsburgh, Pa.
Stone, M. A..........Brooklyn, N. Y.
Stone, P. I............Everett, Mass.
Stone, R. A..........New York, N. Y.
Stoner, C. W........Glendale, Calif.
Stonerod, C. H.....Springfield, Mass.
Storer, N. W......E. Pittsburgh, Pa.
Storey, N. C............Miami, Fla.
Storm, R. E.......Washington, D. C.
Storrow, J. J., Jr.......Boston, Mass.
Storrs, R. S.......Torrington, Conn.
Stosskopf, G. W........Evanston, Ill.
Stouffer, C. S..........Pottstown, Pa.
Stoughton, G. H.........Flint, Mich.
Stout, J. D..........Hartford, Conn.
Stout, V. A..........Oakland, Calif.
Stovel, R. W........Montclair, N. J.
Stowell, H. E....Niagara Falls, N. Y.
Strachan, B. W.......New York, N. Y.
Strachan, G. C........Butler, N. J.
Strader, L. E........Richmond, Ind.
Strader, R. H........Brooklyn, N. Y.
Strahl, O. R........Woodcliff, N. J.
Straight, H. R...........Adel, Iowa
Strang, C. J.........New York, N. Y.
Strate, J. T.........Brookings, S. D.
Stratton, G. W........Buffalo, N. Y.
Stratton, J. A.........Newport, R. I.
Straub, G. H........Brooklyn, N. Y.
Straub, L. G......Minneapolis, Minn.
Straub, T. A........Pittsburgh, Pa.
Straube, E. H.........St. Louis, Mo.
Strauchen, D. M.....Cincinnati, Ohio
Straus, W. R..........Baltimore, Md.
Strauss, B. J.......New York, N. Y.
Strauss, J...........Bridgeville, Pa.
Strauss, J. B....San Francisco, Calif.
Strawn, M. L..........Rockford, Ill.
Strayer, R. K..........Lancaster, Pa.
Strazzabosco, G. J. A...........
Union City, N. J.
Street, C. F........Greenwich, Conn.
Street, E. T......Downingtown, Pa.
Street, G. L., Jr......Richmond, Va.
Street, L. N..........Petersburg, Va.
Streeter, C. O......Shrewsbury, Mass.
Streeter, V. L....Karlsruhe, Germany
Streid, D. D.....Schenectady, N. Y.
Stremmel, P. J.....Granite City, Ill.
Strezynski, G. J..Poughkeepsie, N. Y.
Stricker, A. K., Jr..New York, N. Y.
Strickland, A. W..Big Timber, Mont.
Strickland, B.........Rock Island, Ill.
Strider, I. H.........Wheeling, W. Va.
Stromeier, A. H.......Altoona, Pa.
Stromgren, C. D...Los Angeles, Calif.
Strong, A. J.........Gainesville, Fla.
Stross, C. H.........E. Chicago, Ind.
Strothman, E. P......Milwaukee, Wis.
Strott, J. F.....San Francisco, Calif.
Stroud, E. G.........Cleveland, Ohio
Stroud, M. G....Charlottesville, Va.
Strouse, B. H....Atlantic City, N. J.
Strouse, S. B.....Atlantic City, N. J.
Strowger, E. B.........Buffalo, N. Y.
Stroyan, G. S...........Milford, Pa.
Struben, S. J............Monroe, La.
Struble, G. W........Bethlehem, Pa.
Struck, H. W..........Boston, Mass.
Struckmann, H., 2nd.New York, N. Y.
Strunk, W. O.......New York, N. Y.
Struthers, R. T....Mt. Vernon, N. Y.
Strutz, C. R...........Chicago, Ill.
Stuart, J., 3d......Wilmington, Del.
Stuart, K. E.....Niagara Falls, N. Y.
Stuart, M. C..........Bethlehem, Pa.
Stuart, T. C.........Shanghai, China
Stubblebine, W. A...New York, N. Y.
Stubbs, W. F.......Sarnia, Ont., Can.
Stuckert, F. J.......Milwaukee, Wis.
Stucki, A...........Pittsburgh, Pa.
Studley, G., Jr.......New York, N. Y.
Stueber, G............St. Louis, Mo.

Stuebing, A. F......New York, N. Y.
Stueve, W......Oklahoma City, Okla.
Stuhrman, A. P.........Miami, Fla.
Stults, W. W........Cranbury, N. J.
Stumpf, J...........Berlin, Germany
Stuntz, J. E...........Havana, Cuba
Stunzi, J. J...Briarcliff Manor, N. Y.
Sturgess, J. B...San Francisco, Calif.
Sturken, O. A.......Brooklyn, N. Y.
Sturm, G. W.........Bayonne, N. J.
Styri, H...........Philadelphia, Pa.
Su, N...............Peiping, China
Suczek, R............Detroit, Mich.
Suda, G..............Newark, N. J.
Sudduth, H. N.....Watertown, N. Y.
Sugerman, D. L..Central Falls, R. I.
Suhs, G. H........Rhinelander, Wis.
Suiter, J. R.........Princeton, Iowa
Sulentic, S. A..........Topeka, Kan.
Sullender, W. A.....Texas City, Tex.
Sullivan, E. L.........Boston, Mass.
Sullivan, G. G...San Francisco, Calif.
Sullivan, G. L......Santa Clara, Clif.
Sullivan, J. F., Jr......Chicago, Ill.
Sullivan, P. J.......New York, N. Y.
Sullivan, R. H.........Chicago, Ill.
Sullivan, S. J.......New York, N. Y.
Sullivan, W. E.....Washington, D. C.
Sullo, K...........Jersey City, N. J.
Summerhayes, E. R...Yonkers, N. Y.
Summerhays, L. J...Rochester, N. Y.
Summerlin, I. W......Durham, N. C.
Summers, R. E........Corvallis, Ore.
Summerville, F. R..Ridgewood, N. J.
Sumner, E.........Philadelphia, Pa.
Sumner, H. W.........Seattle, Wash.
Suplee, H. H..........Paris, France
Supové, L............Portland, Ore.
Suppicich, S. J...White Plains, N. Y.
Supplee, W. P......Philadelphia, Pa.
Surowiec, E. J........Franklin, N. H.
Surowiec, R. J.........Chicago, Ill.
Suska, C. R...........Danbury, Conn.
Sussdorff, E. L.......Burlington, Vt.
Suter, A..........New York, N. Y.
Suter, F. F..........Irvington, N. J.
Suter, J. H.......Los Angeles, Calif.
Sutherland, D. M., Jr..Trenton, N. J.
Sutherland, K. W..Dobbs Ferry, N. Y.
Sutherland, R. V....Kansas City, Mo.
Sutherland, W. E......Dumont, N. J.
Sutherland, W. H..Southbridge, Mass.
Sutherling, V. M....Longview, Wash.
Sutphen, W. A......Worcester, Mass.
Sutter, L. G............Tulsa, Okla.
Sutton, E. C.......Wilmington, Del.
Sutton, F..........New York, N. Y.
Sutton, H. M..........Boston, Mass.
Sutton, R. I............Akron, Ohio
Sutton, W. L............Bristol, Pa.
Svec, W. F............Chicago, Ill.
Svehla, J. G.........Columbus, Ohio
Svendsen, H............Oslo, Norway
Svensen, C. L.........Lubbock, Tex.
Svenson, C. L......Cambridge, Mass.
Svenson, R. H....Dobbs Ferry, N. Y.
Swab, E. M..........Barberton, Ohio
Swain P. W.....................
Port Washington, L. I., N. Y.
Swain, W. A.......E. Orange, N. J.
Swan, J. J.........Montclair, N. J.
Swan, S. R. B...........London, Eng.
Swan, W. B........El Segundo, Calif.
Swanberg, F. L......Pittsburgh, Pa.
Swannack, J. D......Springfield, Ill.
Swanson, C. H.....Washington, D. C.
Swanson, C. R.......Dorchester, Mass.
Swanson, H. R.....New York, N. Y.
Swanson, N. W..........Chicago, Ill.
Swanton, A. F.......New York, N. Y.
Swanton, H. R....Los Angeles, Calif.
Swart, A. W......Washington, D. C.
Swasey, A..........Cleveland, Ohio
Sweeney, J. L........Pensacola, Fla.
Sweeney, R. J........Annapolis, Md.
Sweet, A. B..........Pensacola, Fla.
Sweet, C. E...........Detroit, Mich.
Sweet, C. M.......Bridgeport, Conn.
Sweet, F.........Ft. Atkinson, Wis.
Sweet, R. A.........Syracuse, N. Y.
Sweetland, E. J....Piedmont, Calif.
Sweetser, W. J...........Orono, Me.
Sweigard, J. L......Philadelphia, Pa.
Swenson, C. O.........Evanston, Ill.
Swetting, J. R.......Columbus, Ohio
Swift, G. S..........Florence, Mass.
Swift, L. B.........Rochester, N. Y.
Swinburne, R. E.....New York, N. Y.
Swinford, J. K........Houston, Tex.
Switzer, F. G.........Ithaca, N. Y.
Switzer, J. A........Knoxville, Tenn.
Swolak, P. A.........Milburn, N. J.
Swope, B. M.........Pittsburgh, Pa.
Sykes, D. L........Philadelphia, Pa.
Sykes, W..............Chicago, Ill.
Sylvester, A. E......Worcester, Mass.
Sylvester, L. A....Philadelphia, Pa.

Symon, B. G..........St. Louis, Mo.
Symon, M. S........New York, N. Y.
Symonds, N. G.......Pittsburgh, Pa.
Syska, A. G.........New York, N. Y.
Szekely, O. E..........Elmira, N. Y.
Sziklas, E............Hopewell, Va.
Szydlowski, E. J....Dorchester, Mass.

T

Taber, G. A...........Boston, Mass.
Taber, G. H..........Pittsburgh, Pa.
Taber, G. H., Jr....New York, N. Y.
Taber, L. S........Providence, R. I.
Taber, W. D..........Reading, Mass.
Tabit, A. J.............Beirut, Syria
Taborsky, R. A......Cleveland, Ohio
Tacchella, A. A..San Francisco, Calif.
Taddiken, J. F......Honolulu, T. H.
Tafel, R. W.........Philadelphia, Pa.
Taffanel, J.............Paris, France
Taft, T. H.........Cambridge, Mass.
Tag, W.............Brooklyn, N. Y.
Tait, R. S...........Lawrence, Kan.
Takeo, T..............Tokyo, Japan
Talbot, A. N.............Urbana, Ill.
Talbot J. M...Prince Bay, S. I., N. Y.
Talbot, P. A.........New York, N. Y.
Talcott, A. A.........Newark, N. J.
Tallgren, W...........Plymouth, Pa.
Tallmadge, W.......E. Orange, N. J.
Tallman, F. G......Wilmington, Del.
Tallman, W. S.......Pittsburgh, Pa.
Talmage, A. A., Jr..New York, N. Y.
Tanco, A. V..............Cebu, P. I.
Tang, B. G......Schenectady, N. Y.
Tangeman, W. W....Cincinnati, Ohio
Tangerman, E. J....New York, N. Y.
Tankard, D. W.....E. London, Africa
Tann, W. L...........Ansonia, Conn.
Tanner, F. C......Bridgeport, Conn.
Tanner, H. C.......Philadelphia, Pa.
Tanner, H. D.........Hartford, Conn.
Tanner, J. R.........Pittsburgh, Pa.
Tansley, L. R.......Cleveland, Ohio
Taplinger, J. R......Brooklyn, N. Y.
Tapp, H. F........Springfield, Mass.
Tappan, C. O.......New York, N. Y.
Tapparo, J. A...........Lebanon, Pa.
Tatarsky, G. F.......Berlin, Germany
Tate, B. E., Jr..........Dayton, Ohio
Tate, M. C...........Stamford, Conn.
Tate, T. R........Washington, D. C.
Tatman, J. S......Connersville, Ind.
Tattersall, L.........Pittsburgh, Pa.
Taube, H. R.......New York, N. Y.
Taurman, A.......Birmingham, Ala.
Tauson, P. O...Oklahoma City, Okla.
Tautz, H. E.........Milwaukee, Wis.
Tawresey, J. S......Philadelphia, Pa.
Taylor, A.........Washington, D. C.
Taylor, A. C.........Hartford, Conn.
Taylor, A. J. T.Vancouver, B. C., Can.
Taylor, A. L.......Waterbury, Conn.
Taylor, A. O.......Wilmington, Del.
Taylor, A. S.........Elizabeth, N. J.
Taylor, A. W.........Baltimore, Md.
Taylor, A. Y......Washington, D. C.
Taylor, B. W.......Philadelphia, Pa.
Taylor, C. L.......Youngstown, Ohio
Taylor, C. W......New Haven, Conn.
Taylor, D. M.......Vancouver, B. C.
Taylor, E. H......E. Stroudsburg, Pa.
Taylor, E. J., Jr.Pearl Harbor, T. H.
Taylor, G. C............Boston, Mass.
Taylor, G. O...............Cicero, Ill.
Taylor, G. R........New York, N. Y.
Taylor, G. W..........Atchison, Kan.
Taylor, H. B.........Villanova, Pa.
Taylor, H. S..........Sarasota, Fla.
Taylor, H. W........New York, N. Y.
Taylor, I. A........Worcester, Mass.
Taylor, J. G..........Pittsburgh, Pa.
Taylor, J. H.............Chicago, Ill.
Taylor, J. K...........London, Eng.
Taylor, J. O.............Chicago, Ill.
Taylor, J. Wallace...Cincinnati, Ohio
Taylor, J. Wm.........Portland, Ore.
Taylor, M. P.....San Francisco, Calif.
Taylor, N..............Ridgway, Pa.
Taylor, R..........Conowingo, Md.
Taylor, R. B.......Knoxville, Tenn.
Taylor, R. H.......Los Angeles, Calif.
Taylor, R. L.........Cincinnati, Ohio
Taylor, Richard M.Schenectady, N. Y.
Taylor, Robt. M.....Cincinnati, Ohio
Taylor, Roy M....Bound Brook, N. J.
Taylor, W. C.....Washington, D. C.
Taylor, W. H...............Slater, S. C.
Taylor, W. M.........Indianapolis, Ind.
Teaf, J. H............Camden, N. J.
Teague, H. M........Bloomfield, N. J.
Teague, J. U., Jr....Burbank, Calif.
Teague, R. L......Birmingham, Ala.
Teal, E. C............Corning, Calif.
Teall, C. H........New York, N. Y.
Teaze, M. H........New York, N. Y.
Tector, A. D.......Asbestos, Que., Can.
Teed, R. H........Hot Springs, Ark.
Teetor, R. R.........Hagerstown, Ind.
Tefft, H. R..........Rochester, N. Y.
Teichman, W. A.New Brunswick, N. J.
Teichmann, F. K....New York, N. Y.
Teichmann, H. F.....Pittsburgh, Pa.
Telford, M. H.......New York, N. Y.
Teller, S. J.........Hartford, Conn.
Tellis, V. G...............Chicago, Ill.
Ten Eyck, H. R.......Clifton, N. J.
Tenkonohy, F. V......Detroit, Mich.
Tenney, A. B...........Boston, Mass.
Tenney, A. M.......New York, N. Y.
Tenney, E. H...........St. Louis, Mo.
Tenney, T. S.......New York, N. Y.
Terrell, E. A........Charlotte, N. C.
Terrell, W. A.................
Roslyn Heights, L. I., N. Y.
Terrill, F. E.........Bay City, Mich.
Terry, C. D............Kewanee, Ill.
Terry, Carlyle Marshall..Chicago, Ill.
Terry, Chas. M..........Decatur, Ill.
Terry, K. E....Cumberland Mills, Me.
Terry, R. V......Hilton Village, Va.
Terry, S.............Honolulu, T. H.
Terwelp, E. J.............Quincy, Ill.
Terwilliger, H. L.San Francisco, Calif.
Terwilliger, H. R.......Buffalo, N. Y.
Terzian, H. G......Philadelphia, Pa.
Tessitor, F............Portland, Ore.
Test, E. W..............Chicago, Ill.
Tewinkel, G. C......Pullman, Wash.
Tews, B. F. W.......Pittsburgh, Pa.
Texada, A. P., Jr....Beaumont, Tex.
Thaker, S. H......Ahmedabad, India
Thanisch, R. J.........Boston, Mass.
Thas, F. A...........Lancaster, Pa.
Thatcher, C. G......Swarthmore, Pa.
Thayer, P. W.....Minneapolis, Minn.
Thayer, R. E.......New York, N. Y.
Thearle, E. L.....Schenectady, N. Y.
Theilmann, F........Cleveland, Ohio
Theobald, C. D.....New York, N. Y.
Theriault, R. J.....Philadelphia, Pa.
Therkelsen, E........Bozeman, Mont.
Thiel, W. A..............Gary, Ind.
Thielker, H. J.........Hoboken, N. J.
Thielscher, H. G...Washington, D. C.
Thieme, O...........Hartford, Conn.
Thieme, R. B.....Los Angeles, Calif.
Thiessen, L..........Pittsburgh, Pa.
Thithan, K..........Bangkok, Siam
Thoene, F. A.......New York, N. Y.
Tholl, J. F.........Needham, Mass.
Thom, G. B.........Swarthmore, Pa.
Thoma, D..........Munich, Germany
Thomas, A. H........Columbus, Ohio
Thomas, B. M......Philadelphia, Pa.
Thomas, C. C.......Pasadena, Calif.
Thomas, C. W......New York, N. Y.
Thomas, C. Y.........Pittsburg, Kan.
Thomas, E. E.....New Haven, Conn.
Thomas, F.........New York, N. Y.
Thomas, F. H...........Urbana, Ill.
Thomas, F. S..........Tokyo, Japan
Thomas, H. D.......New York, N. Y.
Thomas, H. T.........Lansing, Mich.
Thomas, J. B........Ft. Worth, Tex.
Thomas, J. E........Pittsburgh, Pa.
Thomas, P. H.....Washington, D. C.
Thomas, R. H.......Ansonia, Conn.
Thomas, R. L........Baltimore, Md.
Thomas, R. W........Detroit, Mich.
Thomas, V. P.......Ridley Park, Pa.
Thomas, T. R.Long Island City, N. Y.
Thomas, W. A.......St. Paul, Minn.
Thomas, W. P........Detroit, Mich.
Thomas, W. T..........Lodi, Calif.
Thomason, M. D...Kannapolis, N. C.
Thompson, A. L......Everett, Mass.
Thompson, A. W.......Boston, Mass.
Thompson, C.......Brooklyn, N. Y.
Thompson, C. F.....Rochester, N. Y.
Thompson, D. B....New York, N. Y.
Thompson, D. G...Bridgeport, Conn.
Thompson, D. M...Charleston, W. Va.
Thompson, E. A.......Detroit, Mich.
Thompson, E. H......Curtis Bay, Md.
Thompson, E. S...Schenectady, N. Y.
Thompson, F. J.........Tulsa, Okla.
Thompson, F. M.....Greenville, S. C.
Thompson, G. A......Reading, Mass.
Thompson, Herbert L...Houston, Tex.
Thompson, Hugh L..Waterbury, Conn.
Thompson, H. P....Cincinnati, Ohio
Thompson, J. G. H.....Ludlow, Mass.
Thompson, J. I.......Pittsburgh, Pa.
Thompson, J. J.....Milwaukee, Wis.
Thompson, J. R....Washington, D. C.
Thompson, M. J....Ann Arbor, Mich.
Thompson, O. C.Mountain Lakes, N. J.
Thompson, P. W.......Detroit, Mich.
Thompson, R.....Perth Amboy, N. J.
Thompson, R. A.....Gainesville, Fla.
Thompson, R. C.....Cleveland, Ohio
Thompson, R. E.........Boston, Mass.
Thompson, S..Central Mercedita, P. R.
Thompson, S. E.........Boston, Mass.
Thompson, S. J.Wolverhampton, Eng.
Thompson, T. E..Niagara Falls, N. Y.
Thompson, W. F....New Haven, Conn.
Thompson, Wilfred Gregg........
Los Angeles, Calif.
Thompson, Wm. Graeser........
High Point, N. C.
Thompson, W. G. C.State College, Pa.
Thompson, Wm. Thos........
Toronto, Ont., Can.
Thompson, Wm. Tulloch........
Detroit, Mich.
Thomsen, W. A. V...New York, N. Y.
Thomson, A. MacFarlane........
Newark, N. J.
Thomson, A. Morris...Harrison, N. J.
Thomson, E.........W. Lynn, Mass.
Thomson, F. duP........Chester, Pa.
Thomson, G. H.....Cambridge, Mass.
Thomson, H. M.Salt Lake City, Utah
Thomson, H. W.......S. Gate, Calif.
Thomson, J.........E. Chicago, Ind.
Thomson, J. S.........Newark, N. J.
Thomson, S. G.Flushing, L. I., N. Y.
Thomson, T. K......New York, N. Y.
Thomson, W. G......Brooklyn, N. Y.
Thoren, T. R........Iowa City, Iowa
Thorne, E. D..Rocky Point, L. I., N. Y.
Thornley, R. F......Brooklyn, N. Y.
Thornton, A. F...Spring Valley, N. Y.
Thornton, B. M.....Northwich, Eng.
Thornton, W. F...Mechanicsburg, Pa.
Thornton, W. N.....San Diego, Calif.
Thorp, G. G............Chicago, Ill.
Thorpe, C. J..............Iantha, Mo.
Thorpe, R. H..........London, Eng.
Thorpe, W. A. C........London, Eng.
Thorson, A. W........Detroit, Mich.
Throckmorton, J. W..New York, N. Y.
Throne, R. F...........Denver, Colo.
Thuerk, H. C.......New York, N. Y.
Thuermann, W. J....Milwaukee, Wis.
Thuesen, H. G......Stillwater, Okla.
Thumin, C.........Philadelphia, Pa.
Thumser, R. C........St. Louis, Mo.
Thuney, F. M......Washington, D. C.
Thurlow, O. G.....Birmingham, Ala.
Thurston, E. D., Jr....Sharon, Conn.
Thurston, H. G.......Wantage, Eng.
Tibbals, G. A.......New York, N. Y.
Tiefert, C. G........New York, N. Y.
Tieke, W.........New Kensington, Pa.
Tierney, J. E......Los Angeles, Calif.
Tifft, T. D.........New York, N. Y.
Tifft, W. C.............Chicago, Ill.
Tiger, H. L........New York, N. Y.
Tigert, J. J., Jr....Coral Gables, Fla.
Tilbury, S. R..........Topeka, Kan.
Tilley, J...........New York, N. Y.
Tillquist, D........New York, N. Y.
Tillson, B. F..Upper Montclair, N. J.
Tilson, H............Chicopee, Mass.
Tilton, H. B......Portsmouth, N. H.
Timbs, E............Torrance, Calif.
Timmis, P.........Philadelphia, Pa.
Timoshenko, S..Stanford Univ., Calif.
Timpson, W. Q.......New York, N. Y.
Tindall, E. L...........Chicago, Ill.
Tindall, W. P..............Enka, N. C.
Tinghir, V..Forest Hills, L. I., N. Y.
Tinker, J. B......Charleston, W. Va.
Tinker, O. A.........Columbus, Ohio
Tinker, T..............Buffalo, N. Y.
Titus, E. S..........Knoxville, Tenn.
Tobey, J. E..........Cincinnati, Ohio
Tobey, T. J............Detroit, Mich.
Tobey, W. A.....Watkins Glen, N. Y.
Tobin, R. P.......New York, N. Y.
Tobler, H., Jr.........Maywood, N. J.
Todd, J. H..........Brooklyn, N. Y.
Todd, J. M.........New Orleans, La.
Todd, P. E.........Kansas City, Mo.
Todd, R. H..........Delaware, Ohio
Tode, A. M.........New York, N. Y.
Toensfeldt, K.......New York, N. Y.
Tofani, B. J............Denver, Colo.
Tolman, E. B., Jr.......Chicago, Ill.
Tomford, C. W............Lima, Ohio
Tomford, W. J........St. Louis, Mo.
Tomlinson, C. S........Parsons, Kan.
Tompkins, H. D....Jersey City, N. J.
Tompkins, J. G.....New York, N. Y.
Tompkins, S. A.........Newark, N. J.
Toms, W. E.............Troy, N. Y.
Tooker, L. E........New York, N. Y.
Toothacker, W. S., Jr..Detroit, Mich.
Topping, C. H..Clemson College, S. C.
Torchio, P., Jr......Bronxville, N. Y.
Torok, E.........Elizabethton, Tenn.
Torraco, P........Jersey City, N. J.
Torrance, H.........New York, N. Y.
Torregrossa, S.......Brooklyn, N. Y.
Torrence, G. P.......Cleveland, Ohio
Torres, A.............Santurce, P. R.
Torrey, D. F.......Philadelphia, Pa.
Toulmin, H. A., Jr......Dayton, Ohio
Toussaint, E.........New York, N. Y.
Tower, J. W.........New York, N. Y.
Towers, J. F........New York, N. Y.
Towl, F. M.........New York, N. Y.
Towle, H. P.......St. Johnsbury, Vt.
Town, F. E........New York, N. Y.
Towne, J. M..........Holyoke, Mass.
Towne, T...........New York, N. Y.
Towner, J. E........New York, N. Y.
Townsend, A. C.....New York, N. Y.
Townsend, A. F., Jr..Worcester, Mass.
Townsend, C. D..W. Hartford, Conn.
Townsend, H. P.......Hartford, Conn.
Townsend, H. W......Maurer, N. J.
Townsend, J. E......Cleveland, Ohio
Townsend, J. S............Chicago, Ill.
Townsend, L. M...........Lodi, N. Y.
Townsend, N. F....New York, N. Y.
Townsend, W......New Haven, Conn.
Townsend, W. R.......Brooklyn, N. Y.
Towse, H. R........New York, N. Y.
Toyne, J. W............S. Bend, Ind.
Tozer, S. J..............Chicago, Ill.
Traber, A.............St. Louis, Mo.
Track, F. A......Washington, D. C.
Tracy, L. E..............Detroit, Mich.
Tracy, L. S..........Syracuse, N. Y.
Tracy, S. J., Jr......Pittsburgh, Pa.
Traeger, C. H........La Carne, Ohio
Trager, L..............Newark, N. J.
Trail, J. A......College Station, Tex.
Trainer, J. E.........Barberton, Ohio
Transou, A. J......Drumright, Okla.
Tranzen, K..............Chicago, Ill.
Trapnell, J. M...........Newnan, Ga.
Trapnell, N. M........Richmond, Va.
Trashutin, I. Y.....Kharkov, U.S.S.R.
Trask, W. H., Jr..Salt Lake City, Utah
Traudt, W. F..........Buffalo, N. Y.
Traver, A. E.........Brooklyn, N. Y.
Travis, L. J.............Chicago, Ill.
Traxler, E. R............Akron, Ohio
Trayler, W. A., Jr....Barberton, Ohio
Treadwell, B...........Dayton, Ohio
Treat, B. F..........Annapolis, Md.
Treat, F. G.........Worcester, Mass.
Treat, R. M........Manchester, Conn.
Treff, A.................Chicago, Ill.
Trefny, L. E..........Hoboken, N. J.
Treiber, K. L..........Newark, N. J.
Treiber, O. D...........Canton, Ohio
Treloar, J. B....Toronto, Ont., Can.
Trench, W. H......Jersey City, N. J.
Trenck, E. F.....New Rochelle, N. Y.
Trenor, A. D........Gloucester, Mass.
Trenor, F. R...........Lancaster, Pa.
Treschow, K. F......Pittsburgh, Pa.
Treschow, M........New York, N. Y.
Trescott, D. A........Cleveland, Ohio
Tresillian, S. D........Staines, Eng.
Tresouthick, S. G....W. Orange, N. J.
Trethaway, J. D....New York, N. Y.
Trethaway, W., Jr....Trenton, N. J.
Tribe, J.............W. Allis, Wis.
Trinder, F. J.........Biddeford, Me.
Trinkle, R. J..........Lexington, Va.
Trinks, W............Pittsburgh, Pa.
Tripp, L. H........Washington, D. C.
Trishman, H. A.........Akron, Ohio
Trofimov, L. A.......Cleveland, Ohio
Troger, G. F........New York, N. Y.
Troger, H. H., Jr................
New Brunswick, N. J.
Trojanoski, H. V.....Branford, Conn.
Trosper, R. S.........Louisville, Ky.
Trost, H. J........Union City, N. J.
Trost, P. A........New York, N. Y.
Troth, H. C...........Pensacola, Fla.
Trotter, A. H..........Hopewell, Va.
Trotter, R. A.............Atlanta, Ga.
Trounstine, L. J., Jr..New York, N. Y.
Troup, J. D............London, Eng.
Trout, W. C.............Lufkin, Tex.
Trowbridge, A........Eastford, Conn.
Trowbridge, F. C.....Hamilton, Ohio
Troy, M..............Brooklyn, N. Y.
Truax, W. H........Stamford, Conn.
True, C. H..............Chicago, Ill.
True, G. R.............Detroit, Mich.
True, L. M..........Cleveland, Ohio
True, R. M...........Hampton, N. H.
Truedsson, G. R......Hartford, Conn.
Truett, B. S.....San Francisco, Calif.
Trulson, A. F.........La Pointe, Wis.
Truman, F.......Toronto, Ont., Can.
Trumbull, A. G.......Cleveland, Ohio
Trummer, D. J..San Francisco, Calif.
Trump, C. C........Philadelphia, Pa.
Trump, E. N..........Syracuse, N. Y.
Trump, H. W..............Dallas, Tex.
Trumpler, P. R....New Haven, Conn.
Truxal, O. S..............Manor, Pa.
Tschorn, F. H.......Bennington, Vt.
Tsvetkoff, A. P..San Francisco, Calif.
Tucker, J. M..........Knoxville, Tenn.
Tucker, R. N........Columbus, Ohio

Tucker, S. A........Brooklyn, N. Y.
Tucker, W. B........Milwaukee, Wis.
Tuechter, A. H.....Cincinnati, Ohio
Tufts, L. R.........Hillsdale, N. J.
Tullar, I...........New York, N. Y.
Tulloch, W. A.......New York, N. Y.
Tulus, E. A...........Detroit, Mich.
Tunnadine, J...........London, Eng.
Turco, L..............Caracas, S. A.
Turitz, M..........New York, N. Y.
Turk, J. C..........Rochester, N. Y.
Turley, C..............Lindale, Ga.
Turnbull, G. B....River Rouge, Mich.
Turnbull, W. F......Tuckahoe, N. Y.
Turner, C............New York, N. Y.
Turner, C. H........Worcester, Mass.
Turner, C. P..............Pekin, Ill.
Turner, F. B..........Raleigh, N. C.
Turner, G. S.........Memphis, Tenn.
Turner, L............Baltimore, Md.
Turner, M. C..........Oaklyn, N. J.
Turner, O. L.......Washington, D. C.
Turner, R. E...........Chicago, Ill.
Turner, W. C..........Mexico, Mex.
Turner, Wm. Payson...........
W. Lafayette, Ind.
Turner, Wm. Pearson...Norwood, Pa.
Turner, W. W., Jr.........York, Pa.
Turno, W. G..........E. Orange, N. J.
Turnwald, W........Milwaukee, Wis.
Turpin, W. D....Salt Lake City, Utah
Turzicky, F. C..........Chicago, Ill.
Tuthill, E. S........E. Orange, N. J.
Tutt, C. L., Jr..........Flint, Mich.
Tuttle, I. E...Great Neck, L. I., N. Y.
Tuttle, N. J..........Norristown, Pa.
Tuttle, P. W.......New Britain, Conn.
Tuttle, W. B......San Antonio, Tex.
Tuve, G. L..........Cleveland, Ohio
Twaddell, R. W................
Hastings-on-Hudson, N. Y.
Twinberrow, J. O......London, Eng.
Twining, W. S...........Ambler, Pa.
Twitchell, C. H.........Hopewell, Va.
Twyman, L. R...........Detroit, Mich.
Tyack, G. N........Waterbury, Conn.
Tyberg, O.........Point Loma, Calif.
Tyler, C. C..........Hartford, Conn.
Tyng, A...............Buffalo, N. Y.
Tyroff, C. E...........Elizabeth, N. J.
Tyson, J. S. Y......Philadelphia, Pa.

U

Ucko, B............Plainfield, N. J.
Udale, S. M...........Detroit, Mich.
Udall, P. A.........New York, N. Y.
Uddenberg, R. C....Cambridge, Mass.
Uebe, E. K............Detroit, Mich.
Uebelacker, C. F.....New York, N. Y.
Uehling, E. A..........W. Allis, Wis.
Uehling, F. F...........Passaic, N. J.
Uger, D. A...........Moscow, U.S.S.R.
Ugrin, N.........Los Angeles, Calif.
Uhde, W............New York, N. Y.
Uhl, E. L., Jr.......Bridgeport, Conn.
Uhl, W. F.............Boston, Mass.
Uhle, D. J..............Coplay, Pa.
Uhlhorn, W. F.......New York, N. Y.
Uicker, J. J............Durham, N. H.
Uihlein, H. C..........Cincinnati, Ohio
Uihlein, W. B..........Milwaukee, Wis.
Ulbert, A...........New York, N. Y.
Ullrich, A. C..........Buffalo, N. Y.
Ulmann, A., Jr.....Philadelphia, Pa.
Ulmschneider, L. A..Rochester, N. Y.
Ulrich, R............Pittsburgh, Pa.
Umbehocker, F.......Hammond, Ind.
Un, K.-P............Hong Kong, China
Underhill, H. L........Baltimore, Md.
Underwood, E. W.............
Garden City, L. I., N. Y.
Underwood, R. C....New York, N. Y.
Ungar, J. S..........Yonkers, N. Y.
Unger, J. S............Chicago, Ill.
Unger, L. F..........Allentown, Pa.
Unis, M. J.........Philadelphia, Pa.
Unkles, E. H........New York, N. Y.
Untermyer, S., 2nd...E. Chicago, Ind.
Updegraff, W. B....Elizabeth, N. J.
Updike, D. M.......New York, N. Y.
Updike, R.........Indianapolis, Ind.
Upham, W. K.....Phillipsburg, N. J.
Upson, M. M........New York, N. Y.
Upton, G. B............Ithaca, N. Y.
Urbauer, H. F..........St. Louis, Mo.
Urschalitz, P. E.......Detroit, Mich.
Usher, G. C...........London, Eng.

V

Vacca, G. A.............Easton, Pa.
Vaiden, J. C......E. Pittsburgh, Pa.
Vail, C. W.............Ithaca, N. Y.
Vail, D. P.........Los Angeles, Calif.
Vail, H. P........Los Angeles, Calif.
Vail, J. J., Jr..........Butler, N. J.
Vaksdal, A...........Corning, N. Y.
Vaksdal, S..........Blue Island, Ill.
Valentine, C. I.......New York, N. Y.
Valentine, C. W....Watertown, N. Y.
Valenza, N. C...........Newark, N. J.
Vallance, A..............Austin, Tex.
Vallier, A. E.........Milwaukee, Wis.
Valmos, L. L........New York, N. Y.
Valuch, J. T............Chicago, Ill.
Van Aken, L. D.........Detroit, Mich.
Vanaman, F H.....Philadelphia, Pa.
Van Artsdalen, J. T..Philadelphia, Pa.
Van Benschoten, J..Toronto, Ont., Can.
Van Bodegom, J....Providence, R. I.
Van Bomel, L. A....New York, N. Y.
Van Brunt, J.......New York, N. Y.
Van Buskirk, G. L...New York, N. Y.
Vance, H. H....Winston-Salem, N. C.
Vance, J. H...........Akron, Ohio
Vance, L. S...........Louisville, Ky.
Vancil, E. D........Cincinnati, Ohio
Van Cleve, H. P...Minneapolis, Minn.
Van de Cop, K..Harrington Park, N. J.
Vandegrift, C. G....State College, Pa.
Van Denburgh, O. A., Jr..Troy, N. Y.
Van Den Heurk, F. A..St. Louis, Mo.
VanDerbeek, W. L....E. Orange, N. J.
Vanderbilt, C.......New York, N. Y.
VanDerhoef, G. N....Mishawaka, Ind.
Vanderhoof, A. H.....Asheville, N. C.
Vanderlip, P. J.......Lansing, Mich.
VanderVeer, M....New Haven, Conn.
VanDerveer, T. W......Buffalo, N. Y.
Vandervoort, L. A........Tulsa, Okla.
VanDervort, A. O..........Troy, N. Y.
Van Deventer, F. M..New York, N. Y.
Van Dongen, D. W............
Grand Rapids, Mich.
Van Dongen, J. R. J...........
The Hague, Netherlands
Van Doren, W. D...............
Jackson Heights, L. I., N. Y.
Van Dusen, C. T.......Detroit, Mich.
Van Dyke, J. R......Bismarck, N. D.
Vane, F. F.........Brooklyn, N. Y.
Van Fleet, H........New York, N. Y.
Van Hamersveld, J. J. N........
Cleveland, Ohio
van Hamont, E. F....New York, N. Y.
Van Hengel, G. H......Detroit, Mich.
Van Horn, C. W. G..Philadelphia, Pa.
Van Kammen, I. J.....Detroit, Mich.
Van Klink, J............Enka, N. C.
Van Law, D............Denver, Colo.
Van Leer, B. R......Gainesville, Fla.
Van Luik, F. W., Jr....St. Louis, Mo.
Van Meter, H...........Beloit, Wis.
Van Ness, F. W..Mountain Home, N. C.
Van Norman, F. D..Springfield, Mass.
Van Riper, F. H....New York, N. Y.
Van Ry, W. H........Seattle, Wash.
Van Schaick, G. D....Scarsdale, N. Y.
Vanselow, J. C....Minneapolis, Minn.
Van Sicklen, W. A., Jr..Gatun, C. Z.
Van Steenwyk, H. W...........
Grand Rapids, Mich.
Van Stone, C..........Reading, Mass.
Van Syckle, A. L......Yonkers, N. Y.
Vant, I. N...........Sugarloaf, Colo.
VanTine, C. H.........Detroit, Mich.
Van Valkenburgh, M..New York, N. Y.
Van Vechten, G. C...Rochester, N. Y.
Van Winkle, G. F., Jr....Ames, Iowa
Van Wyck, P. S...Minneapolis, Minn.
Van Yorx, J. H., Jr..Bridgeport, Conn.
Van Zandt, P. C.........Chicago, Ill.
van Zelm, H. B......Hartford, Conn.
Varady, J. C.....Clarksburg, W. Va.
Varga, G. M..Long Island City, N. Y.
Varian, H. M....River Rouge, Mich.
Varkony, E.........Cincinnati, Ohio
Varley, G...............Halifax, Eng.
Varnado, O. D. M..State College, Miss.
Varnes, S. K.......Wilmington, Del.
Varney, W. W........Baltimore, Md.
Varona, M. C...Central Jaronu, Cuba
Vassar, H. S..........Irvington, N. J.
Vasselli, A. J...........Newark, N. J.
Vasta, J..........Washington, D. C.
Vauclain, S. M.....Philadelphia, Pa.
Vaughan, H. H..Montreal, Que., Can.
Vaughan, J. F.........Boston, Mass.
Vaughan, L. L........Raleigh, N. C.
Vaughn, W. M........Stamford, Conn.
Vaule, S. A.........Providence, R. I.
Vaux, H. K..........Pittsburgh, Pa.
Vawter, W. D..........Whiting, Ind.
Veal, C. B..........New York, N. Y.
Veatch, N. T., Jr....Kansas City, Mo.
Veber, C. P....New Brunswick, N. J.
Veck, M. F.............Chicago, Ill.
Vedder, W. O......Hagerstown, Md.
Veeder, C. H........Hartford, Conn.
Veenschoten, V. V.........Erie, Pa.
Vehslage, H. E.......Eastview, N. Y.
Veinote, T. H......Cambridge, Mass.
Veit, C. J..........Rural Valley, Pa.
Velardo, A. J.........Newark, N. J.
Velcamp, J..........Keyport, N. J.
Vendeleers, A. F....New York, N. Y.
Venn, R. E.........Stillwater, Okla.
Vensel, J. R.........Pensacola, Fla.
Verkamp, W. F......Cincinnati, Ohio
Verkozen, A. J................
Amsterdam, Netherlands
Vernon, C. M.........Bayonne, N. J.
Verrall, G. T...........Reigate, Eng.
Veth, N. D..........Columbus, Ohio
Vetlesen, H. J..........Reading, Pa.
Vexler, L..............Newark, N. J.
Via, G. G..........Newport News, Va.
Viall, W. A........Providence, R. I.
Viberg, E. R....Montreal, Que., Can.
Vickess, S.........Bournemouth, Eng.
Vidosic, J............Hoboken, N. J.
Vieau, B. H...........Liverpool, N. Y.
Vierck, Robt. K..........Urbana, Ill.
Viergutz, C. F., Jr...........
Forest Hills, L. I., N. Y.
Viessman, W.........Baltimore, Md.
Vigelius, F. W....Lake Linden, Mich.
Vigne, A.............St. Louis, Mo.
Vigus, C. T...........Louisville, Ky.
Vila, J. W......Hamilton, Ont., Can.
Villasuso, A. S..............
Tucuman, Argentina, S. A.
Vincent, A. S....New Rochelle, N. Y.
Vincent, E. T.........Detroit, Mich.
Vincent, G. I.........Syracuse, N. Y.
Vincent, H. S.......E. Harwich, Mass.
Vincent, J. G.........Detroit, Mich.
Vincze, A.Jackson Heights, L. I., N. Y.
Vinnedge, E. W......Cincinnati, Ohio
Vinten, E. S......New Haven, Conn.
Viohl, H. K. W.....Wilmington, Del.
Viola, B.............Brooklyn, N. Y.
Viscardi, J. E......New York, N. Y.
Viscusi, W. E......Bridgeport, Conn.
Vitale, R. L..........Brooklyn, N. Y.
Vittucci, R. V......New York, N. Y.
Vlahakes, J. L........Newark, N. J.
Vocelka, J............Chicago, Ill.
Vockell, W. H.......Cincinnati, Ohio
Vogel, W. J........Philadelphia, Pa.
Vogelbach, O..........Newark, N. J.
Vogt, C. W.........Saugatuck, Conn.
Vogt, H. W...........Saginaw, Mich.
Vogt, R. F..........Milwaukee, Wis.
Voigt, H........Darmstadt, Germany
Voigt, L. S.........Granite City, Ill.
Vokac, C. W............Chicago, Ill.
Vokoun, O. H...........Chicago, Ill.
Volck, A. G.....Beverly Hills, Calif.
Volckhausen, W. J.............
W. Englewood, N. J.
Vold, L. H..............Butler, Pa.
Volkhardt, W...........Utica, N. Y.
Voll, W. C.........Cambridge, Mass.
Vollmer, P. L......E. Pittsburgh, Pa.
Vom Lehn, S. E.......Cincinnati, Ohio
Von Bargen, O.......Springfield, Ill.
Von Behren, J. N.....Baltimore, Md.
von der Heyde, G....New York, N. Y.
von Eltz, K...........Passaic, N. J.
von Fabrice, R........Newark, N. J.
von Gontard, A.........St. Louis, Mo.
von Herrmann, C. F., Jr..Mobile, Ala.
von Kármán, T......Pasadena, Calif.
Von Kories, O....Los Angeles, Calif.
Von Ohlsen, L. H..New Haven, Conn.
von Pagenhardt, M.Washington, D. C.
Von Pein, E. J.......Endicott, N. Y.
von Phul, W........New York, N. Y.
Von Rotz, R...........Detroit, Mich.
von Schlegell, F.....Pasadena, Calif.
von Schoenaich, S. F..........
Hamburg, Germany
von Till, L. A.Long Island City, N. Y.
Von Vittinghoff, H..New York, N. Y.
Von Voightlander, O..Jackson, Mich.
von Wehrden, F. W....St. Louis, Mo.
von Zastrow, E......Elizabeth, N. J.
Voorhees, G. T.........Scarboro, Me.
Voorhees, J. R.......New York, N. Y.
Voorhees, S. F......New York, N. Y.
Vopat, W. A..Lynnbrook, L. I., N. Y.
Vose, F. H..........Cleveland, Ohio
Vose, R. W........Cambridge, Mass.
Voshall, L. B.......New York, N. Y.
Voss, D. R..........Davenport, Iowa
Voss, G. P.............Chicago, Ill.
Voss, J. H. H.......New York, N. Y.
Voss, W. F......Cliffside Park, N. J.
Vossbrinck, W. J. H....Seattle, Wash.
Voy, E. L.......San Francisco, Calif.
Voysey, A............Chester, Pa.
Voysey, A. E..........Chester, Pa.
Vreeland, M. A....Asbury Park, N. J.
Vroman, E. C.......Watertown, N. Y.
Vroom, R. C.........Montclair, N. J.
Vuilleumier, A.........Bristol, Conn.
Vunck, D. C.........Wood River, Ill.
Vyas, M. M.........Ahmedabad, India

W

Waage, J. J........New York, N. Y.
Waaland, T........New York, N. Y.
Wachs, C. L.............Chicago, Ill.
Wachs, T...............Chicago, Ill.
Waddell, C. E.........Asheville, N. C.
Waddell, C. L.........Harrison, N. J.
Waddell, G. F...San Francisco, Calif.
Wade, E. Annesley...Elizabeth, N. J.
Wade, Edw. A........Madawaska, Me.
Wade, F. S........Los Angeles, Calif.
Wade, W. A........Germiston, Africa
Wade, W. M.........Westfield, Mass.
Wadia, A. D........Ahmedabad, India
Wadleigh, G. R.......New York, N. Y.
Wadman, H. A........Hartford, Conn.
Wadsworth, G. R....New York, N. Y.
Wadsworth, J. F..........Erie, Pa.
Waechter, J. M.......Cleveland, Ohio
Waechter, W. B........Passaic, N. J.
Waer, R. L..........New York, N. Y.
Waern, A. W..........Canton, N. C.
Wagenseil, E. W......Pittsburgh, Pa.
Wager, R. C.........Columbus, Ohio
Wagner, A..........Brooklyn, N. Y.
Wagner, C. A.........Newark, N. J.
Wagner, C. F., 3rd.......Ardmore, Pa.
Wagner, E. M..Huntington Park, Calif.
Wagner, H. A...........Detroit, Mich.
Wagner, J. G................
Soengei Gerong, Sumatra
Wagner, Jackson J...Brooklyn, N. Y.
Wagner, Jas. J....Washington, D. C.
Wagner, L. E......Providence, R. I.
Wagner, P. G.............Akron, Ohio
Wagoner, G. R., Jr..Philadelphia, Pa.
Wagoner, P. D......New York, N. Y.
Wahl, A. M.........E. Pittsburgh, Pa.
Wahl, H. R.............Chicago, Ill.
Wahrenburg, L. E. F..Pittsburgh, Pa.
Wait, J. F...........New York, N. Y.
Wait, W. B.........New Orleans, La.
Waite, G. T.........Berkeley, Calif.
Waite, W. H.........Cleveland, Ohio
Waitkus, J.........Wellsville, N. Y.
Walcher, E. A......Milwaukee, Wis.
Waldeck, L. E.........Newark, N. J.
Walden, R. R........Baltimore, Md.
Waldron, E. H........Taunton, Mass.
Waldron, F. A......New York, N. Y.
Waldron, J. H..New Brunswick, N. J.
Waldron, J. L........Brooklyn, N. Y.
Waldron, W. H..New Brunswick, N. J.
Wales, C. C..........Cleveland, Ohio
Wales, R...............Havana, Cuba
Wales, R. L.........Kingston, R. I.
Walhovic, J. J......New York, N. Y.
Walkama, T. E......Irvington, N. J.
Walkem, G. A..Vancouver, B. C., Can.
Walker, A. G...Cuyahoga Falls, Ohio
Walker, A. M....Grand Rapids, Mich.
Walker, D. S.......Philadelphia, Pa.
Walker, E. L.........Milwaukee, Wis.
Walker, F. W........Milwaukee, Wis.
Walker, G. S.....Windsor, Ont., Can.
Walker, H. F...........Chicago, Ill.
Walker, H. L.........Brooklyn, N. Y.
Walker, J. B., Jr....New York, N. Y.
Walker, J. E.........Puunene, T. H.
Walker, J. H............Detroit, Mich.
Walker, L. E............Lansdale, Pa.
Walker, N. J......Philadelphia, Pa.
Walker, R. A........Berkeley, Calif.
Walker, R. E.........Bluefield, W. Va.
Walker, R. P....San Francisco, Calif.
Walker, R. W...........Austin, Tex.
Walker, S. G.........Honolulu, T. H.
Wall, W. C............Niantic, Conn.
Wall, W. G.........Indianapolis, Ind.
Wallace, A. L........Brooklyn, N. Y.
Wallace, C. H..........Chicago, Ill.
Wallace, D. S...........S. Bend, Ind.
Wallace, G. Q............Pontiac, Ill.
Wallace, G. W...........London, Eng.
Wallace, H. B., Jr..New York, N. Y.
Wallace, J. H. G...Washington, D. C.
Wallace, L. W...........Chicago, Ill.
Wallace, R. A...........Chicago, Ill.
Wallace, R. G...........Keene, N. H.
Wallace, R. S............Peoria, Ill.
Wallace, Wm. Adam...Seattle, Wash.
Wallace, Wm. Anderson.........
Toronto, Ont., Can
Wallace, W. N........Augusta, Kan.
Wallendorf, C. R....New York, N. Y.
Wallene, G. A.........Cleveland, Ohio
Waller, C. R..........Trenton, N. J.
Waller, P. F. W.......Newark, N. J.
Wallichs, A..Aix la Chapelle, Germany
Wallin, J. W......Williamsport, Pa.
Walloe, R.......Staten Island, N. Y.
Walmsley, G..........Baytown, Tex.
Walsh, C...........Elizabeth, N. J.
Walsh, C. Z......Watkins Glen, N. Y.
Walsh, E. R.........Springfield, Mass.
Walsh, J.............Seattle, Wash.
Walsh, J. H..........Washington, D. C.

Walsh, J. L........New York, N. Y.
Walsh, T. A........Bronxville, N. Y.
Walsh, W. J........Philadelphia, Pa.
Walstad, A. N........Tacoma, Wash.
Walston, W. R..Scotland Neck, N. C.
Walter, F. L........New York, N. Y.
Walter, H. W.......Brooklyn, N. Y.
Walter, J. A........Kansas City, Mo.
Walter, R............Seattle, Wash.
Walters, J. C......Jamestown, N. Y.
Walters, J. E......W. Lafayette, Ind.
Walters, L. J.......San Diego, Calif.
Walters, W. T..........Chicago, Ill.
Walther, P. H.......New York, N. Y.
Walton, A..........Philadelphia, Pa.
Walton, A., Jr.......Westfield, Mass.
Walton, E..........Brooklyn, N. Y.
Walton, H. L.........Detroit, Mich.
Walton, R. W....Montour Falls, N. Y.
Walton, S. B......Los Angeles, Calif.
Wambold, F. H........Detroit, Mich.
Wandel, C..........New York, N. Y.
Wandrey, E...........Chicago, Ill.
Waner, H. E............Akron, Ohio
Wanner, R...........Terre Hill, Pa.
Ward, C............St. Paul, Minn.
Ward, C. E.......Charleston, W. Va.
Ward, H. B., Jr..New Rochelle, N. Y.
Ward, I. C..........Arlington, Mass.
Ward, J. C., Jr....Farmington, Conn.
Ward, J. E.............Tulsa, Okla.
Ward, J. H., Jr.........Chicago, Ill.
Ward, J. W., Jr.....Greenville, Miss.
Ward, L. C..............Troy, N. Y.
Ward, L. D.......Los Angeles, Calif.
Ward, N. F..........Berkeley, Calif.
Ward, R. C...........Corning, N. Y.
Ward, R. H........New York, N. Y.
Ward, S. E............Atlanta, Ga.
Ward, W. E............Chicago, Ill.
Warden, G. L......Los Angeles, Calif.
Warden, H. C.....E. Millstone, N. J.
Wardwell, F. W...............
Gordon Bay, Ont., Can.
Wardwell, H. J.........Berlin, N. H.
Ware, C. L...........Andover, Mass.
Ware, J. S..........New York, N. Y.
Ware, M..............Detroit, Mich.
Ware, W. C...........Taunton, Mass.
Waream, C. E.......Cincinnati, Ohio
Warfel, R. A...........Bristol, Conn.
Waring, E. H..........Ampere, N. J.
Waring, G. H....Grand Rapids, Mich.
Waring, R. W........Brooklyn, N. Y.
Warmington, T. J..Minneapolis, Minn.
Warner, A. L. D..Los Angeles, Calif.
Warner, C. M......Waterbury, Conn.
Warner, D. F........W. Lynn, Mass.
Warner, E. P.......New York, N. Y.
Warner, J. E. A.......Haverhill, Mass.
Warner, J. L.......Wilmington, Del.
Warner, L. T..........Sydney, Aust.
Warner, O. V.........Hamden, Conn.
Warner, R. F., Jr......Tokyo, Japan
Warner, S. T.......New York, N. Y.
Warnke, H. R.......New York, N. Y.
Warr, W..............Passaic, N. J.
Warren, A. K.....Mamaroneck, N. Y.
Warren, F. W..........Paris, France
Warren, G. B......Schenectady, N. Y.
Warren, G. S............Sharon, Pa.
Warren, H. E., Jr......Munhall, Pa.
Warren, J. P............Dania, Fla.
Warren, K. L..................
Riviere du Loup, Que., Can.
Warren, R. E....Randolph Field, Tex.
Warren, R. L.......Cambridge, Mass.
Warren, W. V..........Salina, Kan.
Warshaw, S. G....Johnson City, N. Y.
Washburn, F. E....Philadelphia, Pa.
Washburn, H. O......St. Paul, Minn.
Washburn, J. M......Hartford, Conn.
Washburn, M., Jr..Los Angeles, Calif.
Washburn, W. S......Brockton, Mass.
Washington, L................
Stanford University, Calif.
Wasser, R.........New York, N. Y.
Wassmer, G. W.......New York, N. Y.
Wasson, J. W........Honolulu, T. H.
Wasson, R. A.......New York, N. Y.
Wasvary, R. F.......Hartford, Conn.
Watelet, P. L........Greenwood, R. I.
Water, R. H.........New York, N. Y.
Waterbury, B. H.......Franklin, Pa.
Waterbury, L. C...............
Central Aguirre, P. R.
Waterfall, H. W....Baton Rouge, La.
Waterman, B. F.....Providence, R. I.
Waterman, H. A...............
Yarmouth-North, N. S., Can.
Waterman, R. R....Providence, R. I.
Waterous, C. A..Brantford, Ont., Can.
Waters, D. V.........Kearny, N. J.
Waters, E. O.......New Haven, Conn.
Waters, G. H......Green Pond, N. J.
Waters, V. F........Hamilton, Ohio
Waters, W. L........New York, N. Y.
Watkins, A.........Rochester, N. Y.
Watkins, R. H..Oklahoma City, Okla.
Watkinson, R. M....New York, N. Y.
Watlington, E. H..Hamilton, Bermuda
Watney, J. R.........Seattle, Wash.
Watson, F......New Hartford, Conn.
Watson, H. D........Woodford, Eng.
Watson, H. F.......Philadelphia, Pa.
Watson, H. H.....Minneapolis, Minn.
Watson, H. L.........Trenton, N. J.
Watson, J. S.......Indianapolis, Ind.
Watson, J. W...........Topeka, Kan.
Watson, R. H.........St. Louis, Mo.
Watson, R. M........Pasadena, Calif.
Watson, T. A......Los Angeles, Calif.
Watson, W...........Milwaukee, Wis.
Watson, W. T...Bayshore, L. I., N. Y.
Watt, J. R...........Seattle, Wash.
Watters, J. A......Jersey City, N. J.
Watts, G. W..........Whiting, Ind.
Watts, R. L........New York, N. Y.
Way, A. O., Jr....Schenectady, N. Y.
Way, G. L.........Jersey City, N. J.
Wyant, F. A............Enka, N. C.
Wean, R. J............Warren, Ohio
Weaton, G. F........Josephtown, Pa.
Weaver, C. J.......Waterford, N. Y.
Weaver, E. W...........Toledo, Ohio
Weaver, F. R.......Indianapolis, Ind.
Weaver, J. R.......E. Pittsburgh, Pa.
Weaver, L. H. A.......Beacon, N. Y.
Weaver, W. E.......Philadelphia, Pa.
Weaver, W. H..........Lancaster, Pa.
Webb, B. H...........Detroit, Mich.
Webb, C. L.........New York, N. Y.
Webb, E. W............Chicago, Ill.
Webb, J. B...........Detroit, Mich.
Webb, W. D........Philadelphia, Pa.
Webber, H. M.........Portland, Ore.
Webber, L. E...........Berwick, Me.
Weber, A., Jr.....Schenectady, N. Y.
Weber, A. M........Paulsboro, N. J.
Weber, C. P...........Bradford, Pa.
Weber, E.............Denver, Colo.
Weber, H. S............Atlanta, Ga.
Weber, N...........New York, N. Y.
Weber, O. E...............York, Pa.
Weber, O. L. E.....St. Cloud, Minn.
Weber, P. F.........Brooklyn, N. Y.
Weber, R. L..........Boston, Mass.
Weber, W. C..........Corning, N. Y.
Webre, A. L............Merion, Pa.
Webster, D. C......Hollywood, Calif.
Webster, D. J.........Brooklyn, N. Y.
Webster, D. T., Jr...New York, N. Y.
Webster, F. L.......Cincinnati, Ohio
Webster, H.........Montclair, N. J.
Webster, H., Jr.......New York, N. Y.
Webster, H. D.......Greenville, Pa.
Webster, H. J......Philadelphia, Pa.
Webster, H. P...San Francisco, Calif.
Webster, J. D.......New York, N. Y.
Webster, J. E.......E. Pittsburgh, Pa.
Webster, J. F.........Bethlehem, Pa.
Webster, L. B...........Marion, Ind.
Webster, S. H.......E. Orange, N. J.
Webster, W...........Camden, N. J.
Webster, W. R....Bridgeport, Conn.
Wechsberg, O.......Worcester, Mass.
Weckstein, S. M........Canton, Ohio
Weddell, R. R.........Rockford, Ill.
Weed, D. C...........Denver, Colo.
Weeks, P...............Peoria, Ill.
Wegener, F. A.Gloucester City, N. J.
Wegg, D. S.........New York, N. Y.
Wegman, E. M........Lancaster, Pa.
Wegner, A. A........Wauwatosa, Wis.
Wehe, A. H.........Baton Rouge, La.
Wehr, C. F...........W. Allis, Wis.
Weibel, E. E.........Berkeley, Calif.
Weibull, W.......Stockholm, Sweden
Weichert, A. E.......New York, N. Y.
Weidig, G. R..........Kearny, N. J.
Weidner, P. G...........Tulsa, Okla.
Weiffenbach, J. F....La Grange, Ill.
Weigel, A. C.......New York, N. Y.
Weigel, A. R...........Freeport, Ill.
Weiland, W. F.........Lincoln, Neb.
Weill, M. K.........New York, N. Y.
Weimann, A. F.......Shelton, Conn.
Weimar, H. C.....Providence, R. I.
Weinbaum, R.......New York, N. Y.
Weinberg, H. L.....New York, N. Y.
Weinberg, P. H.....Philadelphia, Pa.
Weiner, L. P............Peoria, Ill.
Weinhold, J. F......New York, N. Y.
Weinland, C. E......Somerville, N. J.
Weinshank, T..........Chicago, Ill.
Weinstein, A.......New York, N. Y.
Weir, The Rt. Hon. Lord........
Glasgow, Scotland
Weir, C. I..........Edgewater, N. J.
Weir, G. E..........Brooklyn, N. Y.
Weir, T. A...................
Casablanca, Morocco, Africa
Weir, W. F..........Edgewater, N. J.
Weis, A. R...Huntington Park, Calif.
Weismann, V.....Los Angeles, Calif.
Weismantle, A. R.............
Middle Village, L. I., N. Y.
Weiss, A...........Beaver Falls, Pa.
Weiss, A. J..........Ridgefield, N. J.
Weiss, C. H.........Hartford, Conn.
Weiss, J. R..........New York, N. Y.
Weiss, L. T.........Brooklyn, N. Y.
Weiss, P. A. H...Poughkeepsie, N. Y.
Weiss, W. L.........Philadelphia, Pa.
Weisselberg, A.......New York, N. Y.
Weissenburger, C. O..........
Point Pleasant, W. Va.
Weisz, M..........New York, N. Y.
Weitzmann, E. J.Niagara Falls, N. Y.
Welanetz, L. F..........Ithaca, N. Y.
Welch, A. E.....Willimantic, Conn.
Welch, C. W...........Boston, Mass.
Welch, G. W.....Fergus Falls, Minn.
Welch, H. A......S. Milwaukee, Wis.
Welch, H. P...........Sheffield, Pa.
Welch, K. B........Mishawaka, Ind.
Welch, L. C............Chicago, Ill.
Welch, L. R.........Philadelphia, Pa.
Welch, N. A....S. Charleston, W. Va.
Welch, W., Jr......New York, N. Y.
Welch, W. P......E. Pittsburgh, Pa.
Welcker, W. A., Jr...Columbus, Ohio
Weld, A. O............Boston, Mass.
Weld, L. G............Carmel, Calif.
Welden, F. D.......New York, N. Y.
Weldon, R. L....Montreal, Que., Can.
Welford, P. G....Toronto, Ont., Can.
Welindt, T. O...........Bradley, Ill.
Wellauer, E. J......Wauwatosa, Wis.
Wellbrock, R.........Brooklyn, N. Y.
Weller, F. E.........Bloomfield, N. J.
Welling, L. H........New York, N. Y.
Wellington, C. O..New York, N. Y.
Wellington, F. C.......Buffalo, N. Y.
Wellington, W. G....Alhambra, Calif.
Wellman, B. L......Worcester, Mass.
Wells, A. S.........Kingsport, Tenn.
Wells, A. W......Los Angeles, Calif.
Wells, B. D..........Danbury, Conn.
Wells, C. G............Tulsa, Okla.
Wells, E. C......St. Petersburg, Fla.
Wells, E. H., Jr....New York, N. Y.
Wells, E. W............Chicago, Ill.
Wells, Geo. E.........St. Louis, Mo.
Wells, Gordon E....Waterbury, Conn.
Wells, H...........Philadelphia, Pa.
Wells, H. E.........Bridgeport, Conn.
Wells, J. M...........Detroit, Mich.
Wells, R. L......Grand Rapids, Mich.
Wells, W. F.........Brooklyn, N. Y.
Wells, W. H...........Chicago, Ill.
Welsh, J. H..........Louisville, Ky.
Welsh, J. R.........Rochester, N. Y.
Welsh, R. W..........St. Louis, Mo.
Welter, G.........New Haven, Conn.
Welton, A. A........Wilmerding, Pa.
Wendel, D. P..........Buffalo, N. Y.
Wender, M..........San Diego, Calif.
Wendes, J. C. H...Naugatuck, Conn.
Wendland, C. F., Sr.New York, N. Y.
Wendschuh, O. H.....Cleveland, Ohio
Wendt, E. F...........Buffalo, N. Y.
Wendt, L. A..........St. Louis, Mo.
Wenghofer, J. D.......Wheeling, Ill.
Wentworth, E. F....E. Orange, N. J.
Wentworth, R. A...Philadelphia, Pa.
Wentworth, S. S.....Mishawaka, Ind.
Wentz, H. H...........Buffalo, N. Y.
Wentzel, A. L..........Reading, Pa.
Wenzel, A. C...........Chicago, Ill.
Werme, A. P..........Palmer, Mass.
Werner, F. W......Ridley Park, Pa.
Werner, H. C.....E. Pittsburgh, Pa.
Werner, O.....Cuyahoga Falls, Ohio
Werner, P...........Bayonne, N. J.
Werner, R...........Ft. Worth, Tex.
Werner, W. A..........Denver, Colo.
Werry, J. A.........Bloomfield, N. J.
Werst, C. W........Philadelphia, Pa.
Werst, H. K........Philadelphia, Pa.
Wert, E. A............Detroit, Mich.
Wertheim, F. E...............
New Brunswick, N. J.
Wertman, D........New York, N. Y.
Wesche, B. A.......Cincinnati, Ohio
Weschler, G. A....Washington, D. C.
Weschler, M. E....Washington, D. C.
Wescott, B. B.........Pittsburgh, Pa.
Wescott, F. L.......Philadelphia, Pa.
Weshler, A...........Brooklyn, N. Y.
Weske, J. R..........Cleveland, Ohio
Wessels, F. S.......Larchmont, N. Y.
Wesson, P. B.......Rochester, N. Y.
Wesson, R..........Rochester, N. Y.
Wesstrom, D. B......Hartford, Conn.
West, A..............Bethlehem, Pa.
West, E. H............Haworth, N. J.
West, F. R............Detroit, Mich.
West, G. A.........Port Deposit, Md.
West, G. H.........Cincinnati, Ohio
West, J. D..........Manitowoc, Wis.
West, J. T........Toronto, Ont., Can.
West, J. W., Jr......New York, N. Y.
West, L. C......Santa Monica, Calif.
West, R. E........Philadelphia, Pa.
West, R. H..........Cleveland, Ohio
Westcott, H. R....New Haven, Conn.
Westerberg, C. F...Bridgeport, Conn.
Westerdahl, A.......Bloomfield, N. J.
Westergaard, V.....New York, N. Y.
Westermaier, F. V..Philadelphia, Pa.
Westervelt, W. I.......Winnetka, Ill.
Westin, C. J........Philadelphia, Pa.
Westington, S. P., Jr...........
San Francisco, Calif.
Weston, C. B............Waldo, Ohio
Weston, J. F......Toronto, Ont., Can.
Weston, R. T...........Madison, Me.
Wethered, W....San Francisco, Calif.
Wetherill, F. V.....Philadelphia, Pa.
Wetherill, R., Jr......Cleveland, Ohio
Wettengel, R. T.....Cincinnati, Ohio
Wetter, P. T........New York, N. Y.
Wettstein, F. A.....Stockholm, Sweden
Wetzel, J. J...........Detroit, Mich.
Wexler, M............Carteret, N. J.
Weyer, L. O.........Brooklyn, N. Y.
Weyker, W. J...........Chicago, Ill.
Weymouth, T. R........Pittsburgh, Pa.
Whallon, J. E.......Brooklyn, N. Y.
Wharton, J. R........Columbia, Mo.
Wheat, O. G......S. Braintree, Mass.
Wheatley, J. G.......New York, N. Y.
Wheaton, W. E.......Plainfield, N. J.
Wheeler, B..Chuquicamata, Chile, S. A.
Wheeler, Chas. H..Northampton, Mass.
Wheeler, Clifton H., Jr.........
Philadelphia, Pa.
Wheeler, F. E.....Binghamton, N. Y.
Wheeler, F. I., Jr.......Newark, N. J.
Wheeler, G. E., Jr..New Haven, Conn.
Wheeler, H. E.......Aruba, D. W. I.
Wheeler, H. W. R....New York, N. Y.
Wheeler, L. J..........Houston, Tex.
Wheeler, S., Jr.........Albany, N. Y.
Whelan, R. J.............Berea, Ohio
Wheless, E. L.........Shreveport, La.
Whetzel, J. C........Pittsburgh, Pa.
Whipp, W. E............Sidney, Ohio
Whipple, G. F.........Boston, Mass.
Whipple, T. T.......New York, N. Y.
Whipple, W........Baton Rouge, La.
Whisler, F. D.......New York, N. Y.
Whitaker, C. H......New York, N. Y.
Whitaker, E........New York, N. Y.
Whitaker, H. E.......New York, N. Y.
Whitaker, J. A..Santa Monica, Calif.
Whitaker, R. J........Newport, R. I.
Whitaker, U. A......N. Canton, Ohio
Whitaker, W. A.....Baton Rouge, La.
Whitcomb, C. F., Jr....Pahokee, Fla.
Whitcomb, L. A...Los Angeles, Calif.
White, A. D...........Boston, Mass.
White, A. E........Ann Arbor, Mich.
White, A. F......Toronto, Ont., Can.
White, A. O....San Francisco, Calif.
White, B..............Denver, Colo.
White, D. A.........Knoxville, Tenn.
White, D. I.............Chicago, Ill.
White, E. F........Rutherford, N. J.
White, E. J............Seattle, Wash.
White, F. O..Edmundston, N. B., Can.
White, G. C............Newark, N. J.
White, H. E............Boston, Mass.
White, H. J..............Lynn, Mass.
White, H. O..........Tacoma, Wash.
White, H. P..........Cleveland, Ohio
White, Jas. C.......Kingsport, Tenn.
White, John C..........Madison, Wis.
White, J. E..........Knoxville, Tenn.
White, J. H..............Miami, Fla.
White, J. L..............Lincoln, Neb.
White, J. R.......Sarnia, Ont., Can.
White, J. W., Jr....New York, N. Y.
White, J. W. H.........Newark, N. J.
White, K. H...............Troy, N. Y.
White, K. K., Jr....Port Arthur, Tex.
White, L. R..........Chatham, N. J.
White, M. G..........Cincinnati, Ohio
White, P. A...........Milwaukee, Wis.
White, P. S..........New York, N. Y.
White, R. E..Long Island City, N. Y.
White, R. H.........Schenectady, N. Y.
White, T...........Paisley, Scotland
White, Weston B....Brooklyn, N. Y.
White, William Braid...Chicago, Ill.
White, William Brooks, Jr......
Philadelphia, Pa.
White, W. E....Montreal, Que., Can.
White, W. H...........New York, N. Y.
White, W. J....Balboa Heights, C. Z.
White, W. M.........Milwaukee, Wis.
Whiteford, A. W....New York, N. Y.
Whiteford, J. F.........London, Eng.
Whitehead, H. G....New York, N. Y.
Whitehurst, J. C......Durham, N. C.
Whiteley, S. M..........Baltimore, Md.
Whitesell, J. E., Jr....Lansdowne, Pa.
Whiteside, S. P.........Chicago, Ill.

Whitfield, R............Atlanta, Ga.
Whitford, R........New York, N. Y.
Witham, J. M......Cambridge, Md.
Whiting, C. W..W. Palm Beach, Fla.
Whiting, E. M..........Chicago, Ill.
Whiting, J. G............Chicago, Ill.
Whiting, R. A.........Riverside, Ill.
Whitley, F. N.......Brooklyn, N. Y.
Whitlock, E. H......Cleveland, Ohio
Whitman, E. B.......Baltimore, Md.
Whitney, H. LeR...New York, N. Y.
Whitney, M. M......New York, N. Y.
Whitney, M. P........Elmira, N. Y.
Whitney, W. M....Winchendon, Mass.
Whitney, W. O......New York, N. Y.
Whiton, H. S...........Chicago, Ill.
Whiton, L. E.....New London, Conn.
Whitsit, L. A.......New York, N. Y.
Whitsitt, W. B.......Baltimore, Md.
Whitt, S. A...........Detroit, Mich.
Whittemore, H. L..Washington, D. C.
Whittier, C. R......New York, N. Y.
Whittlesey, F. E.........Corry, Pa.
Wholean, G. R..W. Springfield, Mass.
Wiberg, C. B.........Shelton, Conn.
Wiberg, O.........Finspong, Sweden
Wiberg, R. E......Philadelphia, Pa.
Wibling, S. E.......New York, N. Y.
Wibom, E. G........Westfield, N. J.
Wichum, V..........Brooklyn, N. Y.
Wick, G. R..........Westfield, N. J.
Wick, J. L., Jr....Youngstown, Ohio
Wickenden, T. H....New York, N. Y.
Wickenden, W. E.....Cleveland, Ohio
Wickersham, J. H.....Lancaster, Pa.
Wickersham, N. R..............
Painted Post, N. Y.
Wicklatz, E. G..........Chicago, Ill.
Wicks, C. P..........Stamford, Conn.
Widau, W. E......Kansas City, Mo.
Widdicombe, R. A.......Chicago, Ill.
Wieber, G. A......Glens Falls, N. Y.
Wiedeman, C. R.....Glendale, Calif.
Wiegand, F. J....Midland Park, N. J.
Wiegand, M. C..........Suffern, N. Y.
Wieland, C. F.......Berkeley, Calif.
Wieland, G. E..........Chicago, Ill.
Wier, J. B., Jr......New Orleans, La.
Wiese, O. H........New York, N. Y.
Wiesner, M. W.....Jamestown, N. Y.
Wiess, B., Jr..........Conroe, Tex.
Wiggin, C., Jr......New Orleans, La.
Wiggin, H. A......Cambridge, Mass.
Wigglesworth, W. F....Passaic, N. J.
Wight, H. C...........Dayton, Ohio
Wightman, F. A........Boston, Mass.
Wigle, R. A..........Yonkers, N. Y.
Wiitanen, W.........Barberton, Ohio
Wikander, O. R.....Pittsburgh, Pa.
Wilber, A.............Fulton, N. Y.
Wilber, D. W..........Boston, Mass.
Wilber, W. B............Fulton, N. Y.
Wilberding, M. X..Washington, D. C.
Wilbur, R. S..........Durham, N. C.
Wilburn, J.............Vernon, Calif.
Wilcox, C. C..........S. Bend, Ind.
Wilcox, C. E..........Chicago, Ill.
Wilcox, D. B......Asbury Park, N. J.
Wilcox, H. B.....Minneapolis, Minn.
Wilcox, H. C.......New York, N. Y.
Wilcox, J. S...........Athol, Mass.
Wilcox, P. S........Kingsport, Tenn.
Wilcox, W. M......Fitchburg, Mass.
Wilcoxson, L. S.....New York, N. Y.
Wild, D. F..........Kearny, N. J.
Wilde, D. R.....Salt Lake City, Utah
Wilde, T. B........Inglewood, Calif.
Wilder, O. L......Binghamton, N. Y.
Wildhaber, E........Rochester, N. Y.
Wildin, G. W.........Pittsburgh, Pa.
Wilding, J. A..........London, Eng.
Wiley, E. C..........Lynchburg, Va.
Wiley, F. H..........Chicago, Ill.
Wiley, R. B., Jr..........Miami, Fla.
Wiley, R. C........Providence, R. I.
Wiley, W. O........New York, N. Y.
Wilford, J. W........Lansing, Mich.
Wilhelem, O. F......Irvington, N. J.
Wilhelm, J....Long Island City, N. Y.
Wilhoit, L. M...........Houston, Tex.
Wilke, W. P., III.Sparrows Point, Md.
Wilkenfeldt, J. W....Pittsburgh, Pa.
Wilkens, J. A.......New York, N. Y.
Wilkins, R.....San Francisco, Calif.
Wilkinson, A. S....E. Orange, N. J.
Wilkinson, F. L., Jr..Knoxville, Tenn.
Wilkinson, G. D., Jr....Newark, N. J.
Wilkinson, J. E.......Canton, N. C.
Wilkinson, T. L.....Davenport, Iowa
Wilkinson-Allen, V. R..........
Wentworth, Eng.
Wilks, A..........Bloomfield, N. J.
Willard, A. C..........Urbana, Ill.
Willard, J. A.......New York, N. Y.
Willard, J. W.......Metuchen, N. J.
Willard, L..........New York, N. Y.
Willcox, G. B........Saginaw, Mich.
Willerton, G. E.........Orange, N. J.
Willett, F. M........Wharton, N. J.
Willey, E. C..........Corvallis, Ore.
Willey, F. W.........Cincinnati, Ohio
Willi, A. B............Detroit, Mich.
Williams, Arthur....E. Chicago, Ind.
Williams, Arthur..Roslyn, L. I., N. Y.
Williams, A. B...........Boston, Mass.
Williams, A. F....Muizenberg, Africa
Williams, C. G......Davenport, Iowa
Williams, Clarence H..Helena, Mont.
Williams, Clayton H.Rockaway, N. J.
Williams, D. G.......Allentown, Pa.
Williams, D. T.....New York, N. Y.
Williams, E........New York, N. Y.
Williams, E. E......Charlotte, N. C.
Williams, E. T......N. Quincy, Mass.
Williams, F. B....Providence, R. I.
Williams, F. H.........Dayton, Ohio
Williams, F. N., Jr..Philadelphia, Pa.
Williams, F. S.......Hartsdale, N. Y.
Williams, F. S. G....New York, N. Y.
Williams, G. C.....Baton Rouge, La.
Williams, G. E....Philadelphia, Pa.
Williams, G. L..........Chicago, Ill.
Williams, G. M....Middletown, Conn.
Williams, H. B.........Dudley, Mass.
Williams, H. E........Calumet, Mich.
Williams, H. G..........Chicago, Ill.
Williams, H. O.......St. Paul, Minn.
Williams, J.........Hartford, Conn.
Williams, J. B..........Atlanta, Ga.
Williams, J. D.......Edge Moor, Del.
Williams, J. G...........Franklin, Pa.
Williams, J. Howard...........
Providence, R. I.
Williams, John Howell..........
New York, N. Y.
Williams, John Humphreys,.....
Providence, R. I.
Williams, L..............York, Pa.
Williams, L. W.....Brooklyn, N. Y.
Williams, M. F......Syracuse, N. Y.
Williams, Marvin W...Houston, Tex.
Williams, Maurice W..Wyncote, Pa.
Williams, N. S.........Baltimore, Md.
Williams, O. G........Winsted, Conn.
Williams, P...........Detroit, Mich.
Williams, P. M. J...........
Mahopac Falls, N. Y.
Williams, R. A..........Beloit, Wis.
Williams, R. G..................
Richmond Hill, L. I., N. Y.
Williams, R. L.........Boston, Mass.
Williams, R. S......New York, N. Y.
Williams, S. C.....New York, N. Y.
Williams, S. L.....New York, N. Y.
Williams, S. S..........Ensley, Ala.
Williams, T. R..........Akron, Ohio
Williamson, C. T...Islip, L. I., N. Y.
Williamson, C. W...Worcester, Mass.
Williamson, D. W.....Holyoke, Mass.
Williamson, G. L......Newark, N. J.
Williamson, G. V.....St. Louis, Mo.
Williamson, H. W..Kansas City, Kan.
Williamson, W. R.......Chicago, Ill.
Williamson, W. S......Newark, N. J.
Willis, C. C......Bound Brook, N. J.
Willis, E. J..........Richmond, Va.
Willis, P. A.......Washington, D. C.
Willis, R. L.........Bethlehem, Pa.
Williston, A. L....Washington, D. C.
Willits, O. W........Saginaw, Mich.
Willits, V. W., Jr..Long Beach, Calif.
Willoughby, V. R...New York, N. Y.
Wills, C. A.......Youngstown, Ohio
Wills, J. G., Jr.......Pittsburgh, Pa.
Willsea, R..........Edgewater, N. J.
Willson, D. S.....Conshohocken, Pa.
Willson, F. N.........Princeton, N. J.
Willson, G. T....Poughkeepsie, N. Y.
Wilmore, J. J..........Auburn, Ala.
Wilmot, R. C......Bridgeport, Conn.
Wilmoth, H. E.......Baltimore, Md.
Wilms, H..............St. Louis, Mo.
Wilson, A., 3rd....Philadelphia, Pa.
Wilson, A. H..........Chicago, Ill.
Wilson, A. J. J. A...Montclair, N. J.
Wilson, B. J........Philadelphia, Pa.
Wilson, C..........Cohasset, Mass.
Wilson, C., Jr......Westfield, N. J.
Wilson, C. D.........W. Allis, Wis.
Wilson, C. E.....Los Angeles, Calif.
Wilson, C. R....W. Palm Beach, Fla.
Wilson, C. W.......New York, N. Y.
Wilson, D. G..........Ft. Wayne, Ind.
Wilson, E. L...........Rumford, R. I.
Wilson, F. G.......Waterbury, Conn.
Wilson, G. C..........Madison, Wis.
Wilson, G. P.......New York, N. Y.
Wilson, G. S..........Seattle, Wash.
Wilson, H. A......Barbourville, Ky.
Wilson, H. D.........Pasadena, Calif.
Wilson, Hamilton M.............
Philadelphia, Pa.
Wilson, Henry M.....Cleveland, Ohio
Wilson, J...........Milwaukee, Wis.
Wilson, Jas. Arthur..Kenmore, N. Y.
Wilson, John Amerman, Jr......
New York, N. Y.
Wilson, Jos. Bancroft....Chicago, Ill.
Wilson, Jos. Buckley...Louisville, Ky.
Wilson, J. C........Milwaukee, Wis.
Wilson, J. D.......New York, N. Y.
Wilson, J. E...........Chicago, Ill.
Wilson, L. A..........Madison, Wis.
Wilson, L. B........Barberton, Ohio
Wilson, L. G......Washington, D. C.
Wilson, L. J.................
Queens Village, L. I., N. Y.
Wilson, M. A........Springfield, Ill.
Wilson, O. W.......New York, N. Y.
Wilson, R. A.........Milwaukee, Wis.
Wilson, R. N....Huntington, W. Va.
Wilson, T..............Chicago, Ill.
Wilson, W. F........Pittsburgh, Pa.
Wilson, W. G.......Jersey City, N. J.
Wilson, W. M........Pittsburgh, Pa.
Wilson, W. R.Amityville, L. I., N. Y.
Wilt, A. D., Jr...New Canaan, Conn.
Wimborough, J. R..Indianapolis, Ind.
Wimmer, L. H.......New York, N. Y.
Winans, R. H.........Houston, Tex.
Winbolt, L. W..........Chicago, Ill.
Winchester, D. L....Piedmont, Calif.
Winchester, H. F.Poughkeepsie, N. Y.
Winchester, M. H....Hartford, Conn.
Windle, A. E.........Cleveland, Ohio
Wines, H. T.........Brooklyn, N. Y.
Wing, R. F..........Attleboro, Mass.
Wing, W. N........New York, N. Y.
Winge, O. O...Flushing, L. I., N. Y.
Winget, R. W.....Garden City, Kan.
Wingo, W. B......Tiptonville, Tenn.
Wingren, R. M..College Station, Tex.
Winholt, E.............Moline, Ill.
Winkels, W. G........Superior, Wis.
Winkler, B. C......Springfield, Ohio
Winkler, L...................
Jackson Heights, L. I., N. Y.
Winship, W. E......New Orleans, La.
Winship, W. R.......Fanwood, N. J.
Winslow, A. M.......Seattle, Wash.
Winslow, P..........New York, N. Y.
Winston, J.....San Bernardino, Calif.
Winter, O. W...........Toledo, Ohio
Winterhalter, F.....New York, N. Y.
Winterrowd, W. H......Chicago, Ill.
Winters, F. H.................
Richmond Hills, L. I., N. Y.
Winther, G. S.......New York, N. Y.
Winthorpe, J.....New Haven, Conn.
Winton, L. B......Greenwich, Conn.
Wintritz, G..........Elizabeth, N. J.
Wintzer, H. C.......Milwaukee, Wis.
Wintzer, R..........Milwaukee, Wis.
Wintzer, R. C......New York, N. Y.
Winzenburger, E. A....Poultney, Vt.
Wiren, R. C.....Toronto, Ont., Can.
Wirshing, A. O..............
Central Mercedita, P. R.
Wirtsén, E..........Cleveland, Ohio
Wischmeyer, C.....Terre Haute, Ind.
Wise, A. S..........Montclair, N. J.
Wise, D. E........New Haven, Conn.
Wise, R. T..........New York, N. Y.
Wiseman, E. J.......Brooklyn, N. Y.
Wiseman, J. T.......Brooklyn, N. Y.
Wislicenus, G. F......Harrison, N. J.
Wisner, H. G., Jr...New York, N. Y.
Wissen, G. G...........Ithaca, N. Y.
Wist, E. B........Emeryville, Calif.
Witherbee, R. G......Syracuse, N. Y.
Witheridge, D. E.....Saginaw, Mich.
Withers, C..........Brooklyn, N. Y.
Witmer, F. P., Jr..Bala-Cynwyd, Pa.
Witt, J. C............Chicago, Ill.
Witt, L. H..............Peoria, Ill.
Witte, F.............Buffalo, N. Y.
Wittig, F. E..........Grasselli, N. J.
Wittman, L........New York, N. Y.
Woal, S. T..........Philadelphia, Pa.
Wobensmith, Z. T., 2nd........
Philadelphia, Pa.
Woehl, F...........Barberton, Ohio
Woehr, F. G.......New York, N. Y.
Woelbing, G. H........Denver, Colo.
Woerwag, C. A.....New York, N. Y.
Wohlberg, G.......New York, N. Y.
Wohlenberg, W. J.New Haven, Conn.
Wohlers, C.........New York, N. Y.
Wohlers, K. E.......New York, N. Y.
Wojtasik, E. M..........Chicago, Ill.
Wolcott, H. A.....W. Hartford, Conn.
Wolf, A. M........New York, N. Y.
Wolf, C. E...........Barberton, Ohio
Wolf, H. C...............Irvine, Ky.
Wolf, I.............New York, N. Y.
Wolf, J...............Chicago, Ill.
Wolf, O............New York, N. Y.
Wolf, R. B.........Longview, Wash.
Wolf, W........Corpus Christi, Tex.
Wolfe, B. J.........Rochester, N. Y.
Wolfe, H. L....Bellmore, L. I., N. Y.
Wolfe, R. C......Los Angeles, Calif.
Wolfe T. F.............Chicago, Ill.
Wolff, J. F., Jr....Philadelphia, Pa.
Wolfsohn, R. S......Milwaukee, Wis.
Woll, I. E..........New York, N. Y.
Wollheim, W. E.....New York, N. Y.
Wollin, E..........Philadelphia, Pa.
Wolsdorf, H. A.....Rockaway, N. J.
Wolters, C. F.....Tonawanda, N. Y.
Wood, A.............Hamilton, Ohio
Wood, A. A...........Glenside, Pa.
Wood, A. B..........Syracuse, N. Y.
Wood, A. C.........Philadelphia, Pa.
Wood, B. F.......New York, N. Y.
Wood, C. E..........Cincinnati, Ohio
Wood, C. R..........Milwaukee, Wis.
Wood, C. S........Rutherford, N. J.
Wood, D..........Palto Alto, Calif.
Wood, E. E............Detroit, Mich.
Wood, E. P.............Alloy, W. Va.
Wood, F. W..........Baltimore, Md.
Wood, H. B........Wilmington, Del.
Wood, H. C.......New York, N. Y.
Wood, H. H............Pittsburgh, Pa.
Wood, H. L..........Massillon, Ohio
Wood, H. O.........Nashville, Tenn.
Wood, I. C.............Denver, Colo.
Wood, J. A...........St. Paul, Minn.
Wood, J. K........New York, N. Y.
Wood, J. L...........Oakhurst, N. J.
Wood, J. M............Albany, Wis.
Wood, J. R........Providence, R. I.
Wood, J. T............Peekskill, N. Y.
Wood, O. L., Jr..Schenectady, N. Y.
Wood, R. A........New York, N. Y.
Wood, Richard H...Clay Center, Kan.
Wood, Russell H.....Worcester, Mass.
Wood, R. L.......Gloversville, N. Y.
Wood, R. S.........New York, N. Y.
Wood, S. V........Wilkes Barre, Pa.
Wood, T. J.........Cleveland, Ohio
Wood, V. L...........Lynchburg, Va.
Wood, W. G.............Chicago, Ill.
Wood, W. R..........St. Paul, Minn.
Woodard, W. E.....New York, N. Y.
Woodcock, J........Greensburg, Pa.
Woodfill, C. R...........Peoria, Ill.
Woodman, W. C......Brooklyn, N. Y.
Woodnorth, P. T.....Dubuque, Iowa
Woodroffe, G. H....Philadelphia, Pa.
Woodruff, DeF. D..Washington, D. C.
Woodruff, H. S.....Larchmont, N. Y.
Woods, B. M.........Berkeley, Calif.
Woods, G. E., Jr..Astoria, L. I., N. Y.
Woods, G. R.......New York, N. Y.
Woods, M. K...........Buffalo, N. Y.
Woods, S. H...................
Aberdeen Proving Ground, Md.
Woodson, R. D....Kansas City, Mo.
Woodward, A. H.........Chicago, Ill.
Woodward, A. J...........Erie, Pa.
Woodward, E. L........Chicago, Ill.
Woodward, H. W.....Baltimore, Md.
Woodward, J. A......Leetonia, Ohio
Woodward, S. M.....Knoxville, Tenn.
Wooldridge, W. W...Lakeport, N. H.
Wooler, E.............Canton, Ohio
Woolfenden, H. L.....Detroit, Mich.
Woolfson, H. D.....New York, N. Y.
Woolley, E. L.......Providence, R. I.
Woolley, H. O.....New York, N. Y.
Woolley, P. O.....New York, N. Y.
Woolley, R. E.......Cleveland, Ohio
Woolrich, W. R..........Austin, Tex.
Woolson, C. G.....Bloomfield, N. J.
Woolson, H. T.........Detroit, Mich.
Woolson, W. D.......Springfield, Vt.
Worcester, H. E.......Boston, Mass.
Worcester, W. B....San Diego, Calif.
Worden, E. P.......Glen Ridge, N. J.
Work, R. P..........Pittsburg, Calif.
Worker, J. G.......Philadelphia, Pa.
Worth, D. B.........Columbus, Ind.
Worth, E. B..........Louisville, Ky.
Worthen, J. H.......Plymouth, N. H.
Worthington, C. C.............
Shawnee-on-Delaware, Pa.
Worthington, C. G...Knoxville, Tenn.
Worthington, E. W......Chicago, Ill.
Worthington, J. A....Baltimore, Md.
Worthley, H. S., Jr............
Flushing, L. I., N. Y.
Wottrich, H...........Newark, N. J.
Wraith, W..........New York, N. Y.
Wray, H. C.....Wichita Falls, Tex.
Wright, A. S.................
St. Johns, Newfoundland
Wright, D. C..........Chicago, Ill.
Wright, D. K.......Cleveland, Ohio
Wright, D. L........Elizabeth, N. J.
Wright, D. M.......Cambridge, Mass.
Wright, E. C..........Pittsburgh, Pa.
Wright, E. F.........Harrison, N. J.
Wright, E. N..........Pasadena, Calif.
Wright, F. E...........Newark, N. J.
Wright, F. W., Jr....Buffalo, N. Y.
Wright, H. E...........Utica, N. Y.
Wright, J. A..........Ontario, Calif.

Wright, Jas. C.......Manteca, Calif.
Wright, Jas. C......Coronado, Calif.
Wright, J. W..........Pittsfield, Ill.
Wright, L. E.......E. Orange, N. J.
Wright, L. K........New York, N. Y.
Wright, M. S......Crystal City, Mo.
Wright, O.............Dayton, Ohio
Wright, P.........Birmingham, Ala.
Wright, P. D........New York, N. Y.
Wright, R. C.......E. Lansing, Mich.
Wright, R. E....Sierra Madre, Calif.
Wright, R. H......E. Pittsburgh, Pa.
Wright, R. V........New York, N. Y.
Wright, R. W.........Boston, Mass.
Wright, T. E.......Jersey City, N. J.
Wright, T. P........New York, N. Y.
Wright, W......Newport, News, Va.
Wright, W. H.......New York, N. Y.
Wright, W. Q...San Francisco, Calif.
Wrigley, C. C.........Detroit, Mich.
Wu, K. C...........Shanghai, China
Wuest, L. L........New York, N. Y.
Wunderlich, M. S....St. Paul, Minn.
Wunsch, J. W........Brooklyn, N. Y.
Wurdack, H...........St. Louis, Mo.
Wurgel, R. A......Weehawken, N. J.
Wurster, W. F......New York, N. Y.
Wurth, F........Port Chester, N. Y.
Wyatt, DeW. H......Columbus, Ohio
Wyatt, E. B..........Reading, Mass.
Wyburn, W.........New York, N. Y.
Wyckoff, G. I..........Casper, Wyo.
Wyckoff, J. W.........Hampton, Va.
Wyckoff, N. W......E. Orange, N. J.
Wyer, S. S..........Columbus, Ohio
Wyeth, N. C.......Chadds Ford, Pa.
Wyld, J. H..Garden City, L. I., N. Y.
Wyler, C. J........New Orleans, La.
Wylie, H. M.......S. Norwalk, Conn.
Wylie, J. S.........Granite City, Ill.
Wyllie, J. S.........E. Orange, N. J.
Wyman, E.........Little Falls, N. Y.
Wyman, G. R., Jr..E. Walpole, Mass.
Wyman, L. W.......Berkeley, Calif.
Wynkoop, N. O......New York, N. Y.
Wynn, F. C........Bartlesville, Okla.
Wynne, J. T..........Waltham, Mass.
Wynne, T. N.......Indianapolis, Ind.
Wynns, C. B........Columbus, Tenn.
Wyrick, H. B......W. Branch, Mich.
Wyrzywalski, S...New Bedford, Mass.

Y

Yamamoto, T......New York, N. Y.
Yambert, D. W......Knoxville, Tenn.
Yanagihara, H.......New York, N. Y.
Yanosik, A. J........Hartford, Conn.
Yarnall, D. R......Philadelphia, Pa.
Yarrow, H. E.....Glasgow, Scotland
Yates, J. L...........Buffalo, N. Y.
Yates, R. C.........Cincinnati, Ohio
Yates, R. L...............Erie, Pa.
Yeakel, A. E.........Princeton, Ind.
Yeaton, P. O........Gainesville, Fla.
Yee, O. K.............Dayton, Ohio
Yellott, J. I..........Hoboken, N. J.
Yeo, E. J.........Pearl River, N. Y.
Yerzley, F. L.......Wilmington, Del.
Yesowitz, M.........Brooklyn, N. Y.
Yewdall, F. M......Philadelphia, Pa.
Yingling, F. B.......Hamilton, Ohio
Yocom, L. F., Jr....New York, N. Y.
Yoder, D. M.........Barberton, Ohio
Yoder, H. D...........Detroit, Mich.
Yoerger, F....Rego Park, L. I., N. Y.
Yohe, C. H...........Lakeland, Fla.
Yoshinari, M...Yokosuka City, Japan
Yost, C. J., Jr........Seattle, Wash.
Yost, L............Milwaukee, Wis.
Yost, S. H...........Columbus, Ohio
Youell, L. L..........Hopewell, Va.
Young, A. J.........Milwaukee, Wis.
Young, A. P........Houghton, Mich.
Young, B. B........Pilot Point, Tex.
Young, C. H........New York, N. Y.
Young, C. J...........Boston, Mass.
Young, C. M., Jr....Philadelphia, Pa.
Young, D. L........New York, N. Y.
Young, E. G............Urbana, Ill.
Young, G. Alden.......Kearny, N. J.
Young, Gilbert A..W. Lafayette, Ind.
Young, G. S.......Huntertown, Ind.
Young, H. R.......Philadelphia, Pa.
Young, J. D..........Waterloo, Iowa
Young, J. E....Cuyahoga Falls, Ohio
Young, J. H., Jr..............
E. Charleston, W. Va.
Young, J. M.........Honolulu, T. H.
Young, Jas. Winfield.....Altoona, Pa.
Young, John W................
Pacific Palisades, Calif.
Young, P. A.........Montclair, N. J.
Young, P. J., Jr......Buffalo, N. Y.
Young, P. M...........Butte, Mont.
Young, R...........Grandfield, Okla.
Young, R. H......Port Huron, Mich.
Young, R. T........Littleton, N. H.
Young, Selah P....Washington, D. C.
Young, Stanley P.........Orono, Me.
Young, T. F..........Erlton, N. J.
Young, V. W........Stillwater, Okla.
Young, W. H., Jr.....Paterson, N. J.
Young, W. V...........Chicago, Ill.
Youngclaus, W. P., Jr.........
Sweetwater, Tex.
Younger, J..........Columbus, Ohio
Younglove, E. H........Chicago, Ill.
Youngson, A. C....Dobbs Ferry, N. Y.
Youtsey, F. S........Collinsville, Ill.
Yulke, S. G.........New York, N. Y.

Z

Zabriskie, C. I..Totowa Borough, N. J.
Zacek, O. S...........Detroit, Mich.
Zachert, A. R.......New York, N. Y.
Zack, E. S............Detroit, Mich.
Zack, E. T..........New York, N. Y.
Zademach, E. R.....New York, N. Y.
Zaffarano, V. M.....New York, N. Y.
Zahlen, J. V............Chicago, Ill.
Zahn, O. F., Jr........Detroit, Mich.
Zalkind, A. M.......New York, N. Y.
Zalkind, B. J.........Biddeford, Me.
Zap, H............New York, N. Y.
Zapf, N. F...............Troy, N. Y.
Zarobsky, I. F..........Toledo, Ohio
Zartarian, E........Worcester, Mass.
Zaunmiller, E. W....New York, N. Y.
Zautner, N. G......Philadelphia, Pa.
Zeder, F. M...........Detroit, Mich.
Zehr, V. A....................
Stara Boleslav, Czechoslovakia
Zeiner, E. F........Philadelphia, Pa.
Zeise, K. S.........Wilmington, Del.
Zeitzoff, S...........Brooklyn, N. Y.
Zeliff, D. E..........Arlington, N. J.
Zeller, J. W...........Boston, Mass.
Zemke, A. W...........Chicago, Ill.
Zenatý, B.....Prague, Czechoslovakia
Žepernick, W...........Chicago, Ill.
Zepht, E. E............Linden, N. J.
Zerban, A. H.......State College, Pa.
Zieber, W. E..............York, Pa.
Ziegler, J. W.......New York, N. Y.
Ziegler, W. L........Woodcliff, N. J.
Zietlow, F. P......Indianapolis, Ind.
Zieve, W. A......W. New York, N. J.
Zilboorg, J. M..........Mexico, Mex.
Zilen, V. W........Chickamauga, Ga.
Zimmerli, F. P........Detroit, Mich.
Zimmerlund, L. E..Washington, D. C.
Zimmerman, C..........Chicago, Ill.
Zimmerman, C. D.......Akron, Ohio
Zimmerman, E. W....Syracuse, N. Y.
Zimmerman, F. R......Superior, Wis.
Zimmerman, G. F...Union City, N. J.
Zimmerman, H......Kansas City, Mo.
Zimmerman, H. T..Hackensack, N. J.
Zimmerman, J. H......Newark, N. J.
Zimmerman, O. B.....LaGrange, Ill.
Zimmerman, R. E.....Baltimore, Md.
Zimmerman, R. M...Kansas City, Mo.
Zimmermann, J. E..Philadelphia, Pa.
Zink, G. A.........Indianapolis, Ind.
Zinsser, A., Jr.....Bridgeport, Conn.
Zober, W...........Brooklyn, N. Y.
Zohe, L. A...........Syracuse, N. Y.
Zoll, S. W..........New York, N. Y.
Zook, S. O...........Mifflintown, Pa.
Zouck, G. H........New York, N. Y.
Zouraeff, A..........Brooklyn, N. Y.
Zowski-Zwierzchowski, S. J.....
Warsaw, Poland
Zsuffa, L. F........New York, N. Y.
Zuberbuehler, P...Berne, Switzerland
Zublin, J. A......Los Angeles, Calif.
Zuckerberg, H....Los Angeles, Calif.
Zuckerman, N. E.....Gorki, U.S.S.R.
Zucrow, M. J...........Chicago, Ill.
Zuerl, C. D...........Centralia, Mo.
Zullo, S...........Jersey City, N. J.
zur Nedden, F.......Berlin, Germany
Zuzuly, W. S...........Chicago, Ill.
Zvonecek, J. W.......Brookfield, Ill.
Zwack, R. T.........E. Orange, N. J.
Zwick, B. F..................
Barranca-Bermeja, Colombia, S. A.
Zwimpfer, E. A........London, Eng.
Zwingli, C. T......Hawthorne, N. J.

GEOGRAPHICAL LIST OF MEMBERS

UNITED STATES OF AMERICA

Including Territories and Dependencies

ALABAMA

ALABAMA CITY, Birmingham Section

BRAKEMAN, Roy E. ('11), Engr., Charge Design, Gulf States Steel Co., Alabama City; *for mail,* 629 Turrentine Ave., Gadsden.

ANNISTON, Birmingham Section

CARRINGTON, Frank G. ('28), 1030 Christine Ave.

AUBURN, Birmingham Section

DIXON, Solon (J'27), Prof. M. E., Ala. Poly. Inst.; *for mail,* Box 2221.
HIXON, Chas. R. ('21), Asst. Dean, Prof. M. E., Ala. Poly. Inst.
WILMORE, John J. ('93), Dean Engrg., Ala. Poly. Inst.

BIRMINGHAM, Birmingham Section

BARR, Clarence D. ('15; '35), V. P., Am. Cast Iron Pipe Co., P. O. Box 2603.
BARRY, Jas. M. ('23), V. P., Charge Opera., Ala. Power Co.
BENTLEY, Geo. L. (A'21), Sales Engr., Ingersoll-Rand Co., 1700—3rd Ave., S.
BLAIR, Abbott H. ('27), Contracting & Engrg., 838 Martin Bldg.
BROTZMAN, Irvin C. ('28; '35), Supt., Lone Star Cement Corp., 1812 Comer Bldg.
BUELL, J. E. (J'33), Jr. Engr., Stockham Pipe Fittings Co., 4000 N. 10th Ave.; *for mail,* 2108 S. 11th Ave.
CAINE, Wm. P. ('99; '04; '18), 2215 Ave. H, Ensley Sta.
CARPENTER, Thos. J. ('19; '22; '35), Asst. Supt., Thomas Wks., Republic Steel Corp.
CLEM, W. Martin (J'34), Duke Bros. Furniture Co., 1816—3rd Ave.; *for mail,* Apt. 7, 3428—8th Ave., S.
COLE, Harry (J'27), Asst. Gen. Foreman, Tenn. Coal, Iron & R. R. Co., Birmingham; *for mail,* Route 1, Box 561, Bessemer.
CORK, Linn C. (J'34), Draftsman, Stockham Pipe Fittings Co., 4000—10th Ave., N.; *for mail,* 1515 N. 15th Court.
COTLIN, J. W. ('32; '35), 1119 N. 25th St.
DANIEL, Kenneth Rule (J'36), M. E., Am. Cast Iron Pipe Co.
DAVIS, Chas. Baker ('15), C. B. Davis Engrg. Co., 1000—43rd St., S.
DEARING, E. Richard ('24; '35), Designer, Tubize Chatillon Corp., Rome, Ga.; *for mail,* 631—9th Court, S., Birmingham, Ala.
DUGGER, Neal (A'18), Ch. Scale Inspr., Tenn. Coal, Iron & R. R. Co., P. O. Box 100, Ensley.
ESHELMAN, Jos. W. (A'26), Pres., Treas., Eshelman & Potter, 1116 Martin Bldg.
FRANCIS, T. M. ('25), Cons. Engr., 334 Brown-Marx Bldg.
FREEMAN, Henry Livingston ('17), Field Office Engr., Indus. Water Supply Comm., 501 Martin Bldg.; *for mail,* 2132—15th Ave., S.
GALLOWAY, Wm. S. (J'31), Lub. Engr., Sales Dept., Gulf Refining Co., New Orleans, La.; *for mail,* P. O. Box 737, Birmingham, Ala.
GETZEN, John E. ('25; '28; '35), Ch. Engr., Stockham Pipe Fittings Co.; *for mail,* 401 Yorkshire Dr.
GILFILLAN, John M. ('23), Owner, John M. Gilfillan & Associates, 416-17 Lyric Bldg.
GRACEY, Matthew, Jr. (J'36), Continental Gin Co.
GREAGAN, John J. ('17; '21), Dist. Mgr., Allis-Chalmers Mfg. Co., 815-16 Webb Crawford Bldg.
GULDBERG, Dan H. ('21; '35), M. E., Design & Constr., Am. Cast Iron Pipe Co.; *for mail,* 2321 Larch Ave.
HAMILTON, Wm. B. ('12), Prod. & Sales Engr., Hardie-Tynes Mfg. Co.; *for mail,* 1412 S. 17th Ave.
HAWN, R. J. ('13), V. P., Charge Opera., Monsanto Chem. Co., Anniston; *for mail,* 75 Mountain Brook Pkwy., Birmingham.
HEGENBARTH, Francis ('23), Sales Engr., Goslin-Birmingham Mfg. Co., Box 631.
INGALLS, R. I., Jr. (J'30), Jr. Engr., Birmingham Tank Co.
JACKSON, C. P., Jr. (J'34), 1027 S. 28th St.
JONES, Russell Eugene ('28), Ch. Engr., Birmingham Tank Co., 720—4th Ave., S.; *for mail,* 1136—10th Pl., S.
KENT, Herbert S. ('15; '18; '21), Sales Rep., Hays Corp. & Carrick Engrg. Co., Michigan City, Ind.; *for mail,* Homewood Sta., Birmingham, Ala.
MARSHALL, Emerson S. (J'36), 2619 Bush Blvd.
MERKEL, Arthur W. ('21), V. P., Charge Prod., Continental Gin Co., 4600—4th Ave., S.
MIDDLEMISS, G. H. ('18; '35), Mgr., Prod. & Trans., Commonwealth & So. Corp. of N. Y., 600 N. 18th St.
MOORE, Jas. W. ('17; '22), Mgr. Research & Engrg. Sales, Am. Cast Iron Pipe Co.
MOORE, W. D. ('21), Pres., Am. Cast Iron Pipe Co., P. O. Box 2603.
MOORE, W. Joe (J'33), Am. Cast Iron Pipe Co.; *for mail,* 207 Mecca Ave., Homewood Sta.
MOUAT, Harry G. ('23; '35), So. Mgr., Whiting Corp., 830 Martin Bldg.
MOXLEY, S. D. ('24; '26; '30), Ch. Engr., Am. Cast Iron Pipe Co.
O'NEIL, Robt. Dravo ('27; '36), Engr., Charge Branch Sales Office, Am. Meter Co., 447 Martin Bldg.
POLGLAZE, R. A. ('31), Mem. of Firm, Polglaze & Basenberg, Engrs., 1118 Webb Crawford Bldg.
RAMSAY, Erskine ('25), Chmn. Board, Ala. By-Products Corp., Webb Crawford Bldg.
REED, Ramsey Marion ('32), So. Sales Mgr., Cent. Fdy. Co., 420 Lexington Ave., New York, N. Y.; *for mail,* 509 Hampton Dr., Hollywood, Birmingham, Ala.
RUITER, Raymond N. ('30; '35), Sales Engr., Rust Engrg. Co., 1127 Martin Bldg.
RYDING, Herbert C. ('00), Pres., Tenn. Coal, Iron & R. R. Co., 1529 Brown-Marx Bldg.
SHANNON, Lester N. ('27; '35), V. P., Charge Factory Prod., Stockham Pipe Fittings Co., P. O. Box 2592.
TAURMAN, Alphonso ('16), Supt. Equip. & Struc., Birmingham Elec. Co., 2100 1st Ave.; *for mail,* 848 S. 41st St.
TEAGUE, Robt. L. (J'34), Fdy. Training, Am. Cast Iron Pipe Co.; *for mail,* 3151 Norwood Blvd.
THURLOW, O. G. ('15), Cons. Engr., So. Div., Commonwealth & So. Corp. of N. Y., 600 N. 18th St.
WRIGHT, Paul ('15; '15; F'36), Manager, '24-'27; Vice-President, '27-'29; Paul Wright & Co., 243 Brown-Marx Bldg.

CHICKASAW

REAST, Worth M. (J'32), Opera., Ala. Power Co.; *for mail,* Box 207.

ENSLEY, Birmingham Section

KOHN, E. J. ('35), Ch., Bur. of Steam Engrg., Tenn. Coal, Iron & R. R. Co.; *for mail,* P. O. Box 35.
OWENS, Emmett Ray (J'32), Asst. Pyrometrist, Tenn. Coal, Iron & R. R. Co.; *for mail,* 2309—20th St.
WILLIAMS, Saml. S. ('17; '35), Combustion & Power Engr., 2316—20th Pl.

FAIRFIELD, Birmingham Section

PALM, Robt. ('18), Checker, Engrg. Dept., Tenn. Coal, Iron & R. R. Co., Brown-Marx Bldg., Birmingham; *home address,* 4933 Farrell Ave., Fairfield.

HUNTSVILLE

JANNETT, Anthony V., III (J'32), Sanitation Officer, Charge Constr., Board of Health, Madison County.

MOBILE

FRIEND, John H. ('21), V. P., Gen. Mgr., So. Kraft Corp.
von HERRMANN, C. F., Jr. (J'33), Service Man, Ala. Power Co., 68 St. Francis St.

MONTGOMERY

AGRELL, Chas. F. ('31), Dist. Engr., Design & Maint., So. Cotton Oil Co.

ROANOKE

QUENELLE, Owen G. (J'28).

SHEFFIELD

LOURIE, Geo. E. (J'35), Asst. M. E., So. Ry. Co.; *for mail,* 712 Raleigh Ave.

TARRANT, Birmingham Section

OZLEY, Geo. R. ('28; '34), M. E., Charge Maint., Design, Constr. & Power Opera., Ala. By-Products Corp.

TUSCALOOSA, Birmingham Section

ANDERS, Louis H. (J'32), Gulf States Paper Corp.; *for mail,* 329 Caplewood.

UNIVERSITY, Birmingham Section

GALLALEE, John M. ('20), Prof. & Head Dept. M. E., Univ. of Ala.
KENNEDY, A. M. ('16), Instr., Sch. of Chemistry, Univ. of Ala.

WILSON DAM

GORDON, J. F. (A'20), Mech. Supvr., Tenn. Valley Authority.

ALASKA

FAIRBANKS

BUTROVICH, Geo. W. (J'34), Dredge Engr., Fairbanks Exploration Dept., U. S. S. R. & M. Co. Box 1170; *for mail,* Box 1381.

ARIZONA

AJO

DuMOULIN, Walter L. ('11; '13; '17), M. E., New Cornelia Branch, Phelps Dodge Corp.

CLARKDALE

DOUGLAS, Geo. M. ('22), Cons. Power Engr., United Verde Copper Co., Clarkdale, Ariz.; *for mail,* Lakefield, Ont., Can.
LANNING, John E. ('29), Ch. M. E., United Verde Copper Co.; *for mail,* Box 283.

DOUGLAS

LEGRAND, Chas. ('17), Cons. Engr., Phelps Dodge Corp.

JOKAKE

EVANS, R. T. ('32), Pres., Evans Constr. Co.

MIAMI

FAUST, Per Alex ('21), M. M., Internatl. Smelting & Refining Co., Inspiration; *for mail,* Box 1057, Miami.
HATHAWAY, Chas. L. (J'26), Test Engr., Power Plant, Miami Copper Co.

PHŒNIX

HEADMAN, Sasha ('25), Partner, Headman-Ferguson, Engrs., 319 Homebuilders Bldg.

SCOTTSDALE

LINCOLN, John C. ('31), R. F. D. 1, Box 141.

TUCSON

REBER, Louis E. ('91), Retired, 459 N. Granada St.

VAIL

DAY, Chas. Corson (J'29), Mgr., Owner "La Posta Quemada."

ARKANSAS

EL DORADO, Mid-Continent Section

ROGERSON, J. B. ('34), Refinery Supt., Ch. Engr., Lion Oil Refining Co.

FAYETTEVILLE, Mid-Continent Section

HOLMES, A. G., Jr. (J'30), Instr., Mech. Engrg. Dept., Univ. of Ark.
PADDOCK, Russell G. ('21; '25; '35), Prof. M. E., Univ. of Ark.; *for mail,* 525 Vandeventer St.
PRICE, Leonard C. ('27; '31), Research Assoc. Prof. M. E., Univ. of Ark.

FORT SMITH, Mid-Continent Section

CORSON, David C. (J'36), Box 257, 211 N. 17th St.
PINCKNEY, Harold W. (J'34), Jr. Engr., U. S. Geol. Survey, 207 Federal Bldg.; *for mail,* 709 Belle Ave.

HOT SPRINGS, Mid-Continent Section

TEED, Ralph H. ('29; '35), Gen. Supt., Citizens Elec. Co., Hot Springs Water Co., Consumers Gas Co.

JASPER, Mid-Continent Section

RYAN, B. E. (J'32), Lieut., Co. 3786, Civilian Conservation Corps.

JONESBORO, Mid-Continent Section

HILL, Ed ('32), Supt., City Water & Light Plant, 411 Union St.; *for mail*, 522 Huntington Ave.

LITTLE ROCK, Mid-Continent Section

CURRAN, R. W. ('23), State Mgr., Ark.-La. Gas Co., 5th & Center St.
FORDYCE, John R. ('99), War Memorial Bldg.; *for mail*, 4821 Crestwood.
MITCHELL, Robt. B. (J'36), 3906 W. 26th St.
STEWARD, Randall W. (J'35), 1400 W. 6th St.

PINE BLUFF, Mid-Continent Section

BRUENING, Walther H. (J'35), Spec. Apprentice, St. Louis Southwest. Ry. Co.; *for mail*, 1002 W. 24th St.
KUECK, Edwin J. ('31), M. E., Cotton Belt Shops, St. Louis Southwest. Ry. Co.
NUNNALLY, Major P. ('23; '31), Ch. Draftsman, St. Louis Southwest. Ry. Co.

STUTTGART, Mid-Continent Section

KING, Ralph M. (J'27), V. P., Ch. Engr., Layne-Arkansas Co.

CALIFORNIA

ALAMEDA, San Francisco Section

CHRISTIANSEN, Paul ('30), Ch. Engr., Dow Pump & Diesel Eng. Co; *for mail*, Box 228.
FLINK, August E. (J'35), 547 Central Ave.
KIESTER, Harry T. (J'36), Engrg. Clerk, Res. Engrs. Office, Boeing Aircraft Co., Pan Am. Airways Co., P. O. Box 445, Alameda, Calif.; *for mail*, 333—30th Ave., S., Seattle, Wash.
KINNISON, Court J. (J'36), 1910 Santa Clara Ave.
SCHMIDBAUER, Wm. (J'27), 1118 Regent St.

ALHAMBRA, Los Angeles Section

BUSSEY, Geo. L. (J'31), Asst. Engr., Am. Liquid Meter Co., 2217 Orange St.; *for mail*, 415 Orange Grove Ave.
CROWLEY, Chas. P. ('20; '23; '35), 129 N. Vega St.
ECKART, Wm. Rankine ('04), Tech. Adviser, C. F. Braun & Co., Alhambra; *for mail*, 1525 Oak Grove Ave., Pasadena.
HALLANGER, Robt. J. (J'35), 1137 S. 2nd St.
HINSHAW, Meral W. (J'36), 612 N. Bushnell.
KAY, Lloyd Dowling ('32), Pres., Kay-Brunner Steel Products, Inc., 999 Meridian Ave.
McGRATH, Philip C. (J'28), Chem. Engr., C. F. Braun & Co., 1200 S. Fremont St.
McKEE, Norman C. (J'33), Engr. of Constr. & Estimating, Steed Bros., Inc.. 5 Stoneman Ave.; *for mail*, 9 N. Vega St.
SMITH, Chas. Herbert ('24; '28; '35), *Student Award*, '24; Dist. Engr., C. F. Braun & Co., 1200 S. Fremont St.
WELLINGTON, Welton G. (J'35), Apt. 1, 1515 S. Sierra Vista.

ALTADENA, Los Angeles Section

HERBERT, C. G. ('00), M. E., Retired, 2855 Tanoble Dr.
JOHNSON, Paul Franklin ('05), Treas., Johnson Serv. Co. of Milwaukee, Wis.; *for mail*, 3100 Maiden Lane, Altadena, Calif.

ANAHEIM, Los Angeles Section

BOVEE, John L., Jr. (J'33), Mgr., Stand. Pump & Engrg. Corp., Manchester & Loara; *for mail*, 189 Buena Vista.
FORD, Frank H. (J'32), Sales Engr., Stand. Pump & Engrg. Corp.; *for mail*, P. O. Box 6.

ANTIOCH, San Francisco Section

PERKINS, Sumner E. (J'30), Asst. Plant Engr., Fibreboard Products, Inc., 1st & L Sts.; *for mail*, 714 D St.

AVENAL, Los Angeles Section

JONES, J. Paul (J'35), Jr. Engr., Stand. Gasoline Co., P. O. Box 97.
PEARSALL, H. S. (J'36), Oper., Stand. Gasoline Co., P. O. Box 97, Avenal; *for mail*, 3301 Clay St., San Francisco.

AZUSA, Los Angeles Section

KENDALL, Howard C. ('19), Secy., Treas., Charge Equip., Truex Chem. Co., R. F. D. Box 136-B.

BAKERSFIELD, Los Angeles Section

ATKINSON, Thos. A. (J'34), 1200 Quincy Ave.
GATES, Leroy G. ('20), Research Engr., Stand. Oil Co. of Calif.; *for mail*, 2008 Brundate Lane.
LEHR, Paul E. (J'28), Box 999.
OLIPHANT, John J. (J'32), Div. Engr., Gen. Petroleum Corp. of Calif., Box 1592; *for mail*, 2316 Niles St.
SCHARPENBERG, Chas. C. ('17; '35), Ch. Engr. Prod. Dept., Stand. Oil Co. of Calif., 225 Bush St., San Francisco; *for mail*, 2300—18th St., Bakersfield.
SELTZER, Richard J. (J'35), Jr. Engr., Design & Estimating, Hopper Mch. Wks., 2315 M St.; *for mail*, 2328 K St.

BENICIA, San Francisco Section

CLEAVELAND, Norman (J'26), Plant Mgr., Yuba Mfg. Co., Benicia; *for mail*, 2532 Cedar St., Berkeley.
MAGGIOLI, Geo. J. (J'36), Office Engr., Yube Mfg. Co., Benicia; *for mail*, 447 Greenwich St., San Francisco.

BERKELEY, San Francisco Section

ADAMS, Francis E. (J'35), Sales Engr., Modutrol Div., Minn.-Honeywell Regulator Co., 2753—4th Ave., S., Minneapolis, Minn.; *for mail*, 1831 San Juan Ave., Berkeley, Calif.
BARTOLERO Carlo (J'30), Ch. Engr., United Iron Wks., 580—2nd St., Oakland; *home address*, 2747 College Ave., Berkeley.
BARTON, Aldrich ('24), 2821 Hillegas Ave.
BAUER, August A. (J'30), Engr., Design & Maint., Stand. Oil Co. of Calif., Richmond; *for mail*, 2642 Cedar St., Berkeley.
BERRY, Robley E. (J'36), Test Man, Enterprise Eng. Corp., 18th & Alabama Sts., San Francisco; *for mail*, 816 Contra Costa Ave., Berkeley.
BOELTER, Llewellyn ('30), Prof., Engrg. Bldg., Univ. of Calif.
CARTER, Harry T. (J'35), Field Engr., Inspc. & Field Design, Stone & Webster Engrg. Corp., P. O. Drawer D, Richmond; *for mail*, 2523 Ridge Rd., Berkeley.
COLLINS, Frank Wyatt ('21), M. E., Pan-Am. Engrg. Corp., Ltd., 820 Parker St., Berkeley; *for mail*, 1425 Cabrillo Ave., Burlingame.
DAWSON, Percy B., Jr. (J'35), Sales Engr., Pelton Water Wheel Co., 2929—19th St., San Francisco; *for mail*, 3067 Bateman St., Berkeley.
FINCH, Carl V. (J'33), 1643 Walnut St.
FOLSOM, Richard Gilman (J'29), Instr., M. E., Univ. of Calif.
GIBBS, Chas. Jas. (J'35), Structural Detailer, Herrick Iron Wks., 14th & Cambell, Oakland; *for mail*, 3118 Eton Ave., Berkeley.
GOULD, Truman L. (J'34), Asst. Wks. Mgr., Johnson Gear & Mfg. Co., Ltd.; *for mail*, 1141 Cornell St.
HOLLANDER, Aladar ('19), Ch. Engr., Byron Jackson Co., Foot of Carlton St.; *for mail*, 2555 Buena Vista Way.
HOWE, Everett D. (J'25), Instr. M. E., Univ. of Calif.
JEFFERY, Ernest Irvin ('23), M. E., Reconstruction-Inspc., Oakland Bd. of Education, 1025—2nd Ave., Oakland; *for mail*, 2208 Dwight Way, Berkeley.
KELLER, Jos. M. ('32), 2330 College Ave.
LANGILIE, Herbert B. ('15), Assoc. Prof. M. E., Emeritus, Univ. of Calif.
LE CONTE, Jos. N. ('06), Prof. M. E., Univ. of Calif., 116 Engrg. Bldg.
LEDGETT, Lowell A. (J'33), Lab. Asst. in M. E., Univ. of Calif.; *for mail*, 2366 Virginia St.
MACMEEKEN, John W. ('23), Hyd. Engr., Byron Jackson Co.; *for mail*, 2805 Benvenue Ave.
MAFFEY, Wm. L. (J'34), Die Design, Paraffine Cos., Inc., Powell St., Emeryville; *for mail*, 725 Hillsdale, Berkeley.
MAHL, Fred W. ('92; '10), Retired, 28 Norwood Ave.
McCALL, Desmond (J'36), Cost Statistician, Columbia Steel Co., Pittsburg; *for mail*, 2533 Durant Ave., Berkeley.
MILLS, Eugene C. ('21), Designing Engr., East Bay Municipal Utility Dist., 512—16th St., Oakland; *for mail*, 2230 Blake St., Berkeley.
MINARIK, Rudolf Glenn (J'30), Dept. M. E., Univ. of Calif.
MOODY, Wm. Montague ('19; '21; '25), Asst. to Gen. Mgr., Besler Systems, 4053 Harlan St., Emeryville; *for mail*, 725 Spruce St., Berkeley.
O'BRIEN, Morrough P. ('29; '35), Prof. M. E., Univ. of Calif.
PAMPHILON, G. M. (J'36), Johnson Gear & Mfg. Co., 8th & Parker St.; *for mail*, 2703 Stuart St.
POTBURY, Alfred H. ('11), 1930 El Dorado Ave.
PUTRYAE, J. E. (J'35), Engr., So. Pac. R. R., 85 Market St., San Francisco; *home address*, Sta. "A," Box 93, Berkeley.
RABER, Benedict F. ('14), Prof. M. E., Univ. of Calif., Rm. 114, Engrg. Bldg.
RAITT, Geo. H. ('21; '28), V. P., Gen. Mgr., Steel Tank & Pipe Co. of Calif., 1100—4th St.
ROLLINS, Fitzhugh S., Jr. (J'30), Research & Devel. Dept., Diesel Research, Stand. Oil Co. of Calif., Richmond; *for mail*, 1111 Milvia St., Berkeley.
RYAN, Jas. F., Jr. (J'35), 661 Neilson St.
SCHOLTZE, Herman J. ('32; '35), Engr., Charge Design; F. A. B. Mfg. Co., Inc., 67th & Vallejo Sts., Oakland; *for mail*, 1802 Sacramento St., Berkeley.
SIBLEY, Robt. ('12; F'36), Vice-President, '21-'23; Exec. Mgr., Univ. of Calif. Alumni Assoc., 301 Stephens Union, Berkeley; *for mail*, Club Drive Apts., 5301 Broadway Terrace, Oakland.
SMITH, Jas. U. ('28), Designer, Pac. Gas & Elec. Co., 245 Market St., San Francisco; *for mail*, 2477 Virginia St., Berkeley.
STEPANOFF, A. J. ('27; '33), *Melville Award*, '32; Design Engr., Byron Jackson Co.; *for mail*, 981 Indian Rock Ave.
WAITE, Geo. T. ('28), Indus. Engr., 2505 Derby St.
WALKER, Robt. A. (J'36), Jr. M. E., Research & Devel. Dept., Fuel Sec., Stand. Oil Co. of Calif., Richmond; *for mail*, Apt. 301, 1760 Walnut St., Berkeley.
WARD, Nairne F. ('21; '34; '35), Asst. Prof., M. E., College of Engrg., Univ. of Calif.; *for mail*, 2330 Rose St.
WEIBEL, E. E. ('36), Instr., M. E. Dept., Univ. of Calif.
WIELAND, Lieut.-Col. Chas. F. ('01), 199 Hillcrest Rd.
WOODS, Baldwin M. ('27), Prof. M. E., Chmn. Dept., Univ. of Calif.
WYMAN, Laurence W. ('16; '30), V. P. Charge Engrg., Calif. Corrugated Culvert Co., 5th & Parker Sts., Berkeley; *for mail*, 517 Spruce St., Oakland.

BEVERLY HILLS, Los Angeles Section

BEESON, Kenneth H. (J'35), Teacher, Indus. Arts, Beverly Hills High Sch., 241 S. Moreno Dr.
VOLCK, A. Geo. ('29), Pres. & Dir., A. Geo. Volck, Inc., Pres., Dir., Asst. Treas., Hawks-Volck Corp., 9441 Wilshire Blvd.

BURBANK, Los Angeles Section

BOWMAN, Casper J., Jr. (J'36), Lockheed Aircraft Corp.; *for mail*, 563 N. Tujunga Ave.
CHIVENS, Clyde C. (J'35), 809 N. Elmwood Ave.
FINKLE, Fred'k C. ('14), Cons. Hydroelec. Engr., F. C. Finkle Engrg. Offices, 346 E. San Fernando Blvd.
GOODALL, Ray G. (J'36), Lockheed Aircraft Corp., 1705 Victory Place; *for mail*, 517 E. Lake St.
GROW, Lieut. Harlow B. (J'29), Co-Pilot, TWA, Inc., Union Air Term.
TEAGUE, Jasper U., Jr. (J'36), Lockheed Aircraft Corp.; *for mail*, 1801 W. San Fernando Blvd.

CAMINO, San Francisco Section

HUGHES, Marion B. (J'36), Boiler Rm. Attendant, Mich. Calif. Lumber Co.; *for mail*, Camino, Eldorado Co.

CARMEL, San Francisco Section

WELD, Lydia G. ('15; '35), R. F. D. 1, Box 51.

CLAREMONT, Los Angeles Section

RUSSELL, Kenneth F. (J'29), Asst. Mgr., Vortox Mfg. Co., 121 S. Alexander St.

COALINGA, San Francisco Section

MEREDITH, Diven (J'36), Associated Oil Co.

COMPTON, Los Angeles Section

EGAN, B. E. (J'35), 2022 E. 131 St.
GAY, Francis R. (J'35), 11818—1st Ave.

CORNING, San Francisco Section

TEAL, Elmo C. (J'36), 1136—6th St.

CORONA, Los Angeles Section

CHAWNER, W. Rupert ('25), Gen. Mgr., Temescal Water Co., 707 Main St.

CORONADO, Los Angeles Section

BARRETT, J. C., Jr. (J'32), Aviation Cadet, U. S. Naval Reserve, Squadron VF-6B, Fleet Air Detachment.
HULSMAN, Herbert W. (J'32), 1412—10th St.
LONGSTRETH, Chas. ('99), 611-A Ave.
LOOMIS, R. C. (J'35), Aviation Cadet, U. S. Naval Reserve, Squadron VF-3B, Fleet Air Detachment.
WRIGHT, Jas. C. ('20; '35), Pub. Wks. Inspr., U. S. Navy, Pub. Wks. Dept., Foot of Broadway, San Diego; *for mail*, 701 J Ave., Box K, Coronado.

COVINA, Los Angeles Section

KNORR, Emson L. (J'32), Draftsman & Cost Accountant, Nigg Engrg. Corp.; *for mail*, 250½ E. Badillo St.

CROCKETT, San Francisco Section

BREIDENSTEIN, Leonard Wm. (J'32), Jr. Engr., Calif. & Hawaiian Sugar Refining Co., Crockett; *for mail,* 276 Funston Ave., San Francisco.

CYPRESS, Los Angeles Section

MACKAY, Thos. R. (J'35), 319 Lahoma St.

DAVIS, San Francisco Section

BROOKS, Fred'k A. ('18; '25; '29), Assoc. Agri. Engr., Calif. Agri. Exper. Sta., Univ. of Calif.; *for mail,* College Park.
PERRY, Russell L. (J'26), Asst. Prof., Agri. Engrg., Asst. Engr., Calif. Agri. Exper. Sta., Univ. of Calif.

DOWNEY, Los Angeles Section

NICHOLS, Harold J. ('28; '35), Ch. Engr., Refinery Power Plant, Gen. Petroleum Corp., 2525 E. 37th St., Vernon; *for mail,* 536 W. 7th St., Downey.

EL SEGUNDO, Los Angeles Section

BEATTIE, Jos. A. ('18; '25), Foreman, Power Dept., Stand. Oil Co. of Calif.; *for mail,* 515 W. Hally Ave.
MYERS, Henry G. (J'30), Engr., Stand. Oil Co. of Calif., El Segundo; *for mail,* 2210 W. 78th Pl., Inglewood.
SWAN, Wallace Beech (J'35), Engrg. Asst., Maint., Stand. Oil Co. of Calif.; *for mail,* Box 8.

EMERYVILLE, San Francisco Section

CHARLTON, Kenneth G. (J'31), Plant Engr., Rheem Mfg. Co. Emeryville; *for mail,* 1138 Bancroft Way, Berkeley.
CRAMER, Jerome (J'36), Mch. Designer, Paraffine Cos., Inc., Emeryville; *for mail,* 83 Eucalyptus Rd., Berkeley.
KASSEBOHM, Walter H. ('30; '34; '35), M. E., Supt. Tool Div., Marchant Calculating Mch. Co., Landregan & Powell Sts., Emeryville; *for mail,* 1329 Peralta Ave., Berkeley.
McCOY, Thos. A. (J'35), Engr., Apex Mfg. Co., Emeryville; *for mail,* 4314 View St., Oakland.
SIMON, Walter (J'34), Asst. Ch. Engr. of Power Plant, Paraffine Cos., Inc., Foot of Power St., Emeryville; *for mail,* Box 552, Walnut Creek.
WIST, Edw. B. (J'35), Draftsman, Shell Devel. Co., 53rd & Horton St., Emeryville; *for mail,* 1216 Bay St., Alameda.

FALL BROOK, Los Angeles Section

KINGSBURY, J. Grant ('06), Pres. & Cons. Engr., Grant Mfg. & Mch. Co., 90 Silliman Ave., Bridgeport, Conn.; *for mail,* Mission Rd., Fall Brook, Calif.

FRESNO, San Francisco Section

BUSWELL, J. Morgan ('30; '35), Gen. Inspr., San Joaquin Light & Power Corp.
CHESS, Gerald E. (J'35), Engr., Charge Maint., San Joaquin Light & Power Corp., Fulton at Toolumne.
HAUGSE, V. S. (J'33), Asst. Engr., U. S. Bur. of Reclamation, P. O. Box 671, Boulder City, Nev.; *home address,* 1025 Roeding Ave., Fresno, Calif.
PRESCOTT, F. Kendrick (J'35), 3707 Huntington Blvd.

GLENDALE, Los Angeles Section

BAENDER, Fred'k G. ('27), Dir., Air Conditioning Div., Hemphill Diesel Schools, 409 Bank of America Bldg.
BOSSERMAN, Chas. A. (J'29), Instr., Design & Stress Analysis, Curtiss Wright Tech. Inst., Grand Central Air Terminal; *for mail,* 632 W. Fairmont.
CHESTER, Ray G. ('27; '35), 118 S. Everett St.
CLARKE, Philip L. ('07; '20), 1530 Cleveland Rd.
HAMPTON, F. W. (J'35), Curtis Wright Sch.
MITCHELL, Lieut. Hewitt F. (J'31), 2nd Pilot, Am. Air Lines, Inc., 1200 Airway.
RHODES, Frank A., Jr. (J'36), Prod. Engr., Lockheed Aircraft Corp., Victory St., Burbank; *for mail,* Y. M. C. A., Glendale.
SEVERY, Victor H. ('29), 500 E. Maple St.
SINGER, S. C., Jr. (J'33), 530 N. Central Ave.
STONER, Chas. W. (J'30), Oper. Engr., Union Ice Co., Glendale; *for mail,* 3973 S. Arlington Ave., Los Angeles.
WIEDEMAN, Chester R. (J'35), 331 E. Fairview Ave.

HEALDSBURG, San Francisco Section

LATTIN, Judson ('91).

HERMOSA BEACH, Los Angeles Section

FULTON, Wm. B. ('17), 1830 Camino Real.

HOLLYWOOD, Los Angeles Section

CERNY, Walter J. (J'30), Project Engr., Northrop Corp., L. A. Municipal Airport, Inglewood; *for mail,* 1020 Cory Ave., W. Hollywood.
WEBSTER, Donald C. (J'36), Jr. Research Fellow, Am. Petroleum Inst., Research Sta. 37, Calif. Inst. of Tech., Pasadena; *for mail,* 1846 N. Van Ness Ave., Hollywood.

HONDO, Los Angeles Section

ADAMS, Lieut.-Col. Walter H. ('08; '12), M. E., Charge Maint., Rancho Los Amigoś, Hondo; *for mail,* 1633 Ard Eevin Ave., Glendale.
GRAEF, Louis F. ('18; '26; '35), Maint. Dept.; Rancho Los Amigos, Hondo; *for mail,* 3614 Norton Ave., Lynwood.

HUNTINGTON PARK, Los Angeles Section

BIGELOW, Geo. E. ('28), Pres., Gen. Mgr., Pac. Pump Wks., 5716 Bicket St.
FULLMAN, C. Arthur ('34; '35), Ch. Engr., Los Angeles Plants, Bethlehem Steel Co., Box 1227, Arcade Sta., Los Angeles; *for mail,* P. O. Box 262, Huntington Park.
HUFFMAN, C. Warren ('36), Cons. Hyd. & Mech. Engr., 5905 Pacific Blvd.
WAGNER, Edmond M. (J'29), *Junior Award,* '32; Kobe, Inc., 3040 E. Slauson Ave., P. O. Box 190.
WEIS, Arthur R. ('27; '35), V. P., Ch. Engr., Pac. Pump Wks., Box 151.

INGLEWOOD, Los Angeles Section

DEVLIN, Leo J., Jr. (J'33), Stress Analyst, Northrop Corp., Inglewood; *for mail,* 4226 S. Bronson Ave., Los Angeles.
FULLER, Geo. B. ('26), 882 Commercial St., E.
JARDH, Wilhelm ('20; '35), Draftsman, Northrop Corp., Inglewood; *for mail,* 1047 W. 64th St., Los Angeles.
WILDE, Thos. B. (J'32), Engr., Design, Sutorbilt Corp., 2008 E. Slauson Ave., Los Angeles; *for mail,* 339 W. Ellis St., Inglewood.

LAGUNA BEACH, Los Angeles Section

MILLER, Spencer, Sr. ('88), Manager, '14-17; Vice-President, '17-19; 661 Glenneyre.

LA HABRA, Los Angeles Section

DODSON, Chas. R. (J'31), Petroleum Engr., Charge Prod., Tech. Lab., Stand. Oil Co. of Calif., P. O. Box 397.
SCHOLEFIELD, Crighton W. ('12; '20; '35), Engr., Maint., Stand. Oil Co. of Calif.; Producing Dept., Box 397, La Habra; *for mail,* 1223 Frances Ave., Fullerton.

LA JOLLA, Los Angeles Section

GOEBEL, Gordon W. ('22; '23), Life Member; Westinghouse Electric & Manufacturing Co., E. Pittsburgh, Pa.; *for mail,* 442 Ravina St., La Jolla, Calif.
HICKS, Geo. C., Jr. ('15), Retired, 7434 High Ave., P. O. Box 539.

LINCOLN, San Francisco Section

BURNET, Edgar E. ('13), Rancher.

LODI, San Francisco Section

THOMAS, Wm. T. (J'30), Asst. Engr., Super Mold Corp., 420 N. Sacramento St.; *for mail,* 611 N. School St.

LONG BEACH, Los Angeles Section

ADAMS, Edw. Thomas ('99), 3001 Cherry Ave.
ANDERSON, Donald M. (J'32), Box 290, Shell Oil Co.
BAKER, Linnaeus E. ('20), M. E., Shell Oil Co.; *for mail,* 744 Chestnut Ave.
CZOCK, Jacob H. ('23; '26; '35), Sales Mgr., West. Div., Atlas Imperial Diesel Eng. Co., 201 Fish Harbor Wharf, Terminal Island, Long Beach; *for mail,* 4124 Lyman Rd., Oakland.
GOWEN, Jas. Robt. (J'36), 154 Santa Ann Ave.
GRANDLE, Paul (J'36), 1017 Cerritos Ave.
KRAPS, Leo J. ('26; '35), Asst. Supt., Steam Generation, So. Calif. Edison Co., Ltd., P. O. Box 771; *for mail,* 243 Park Ave.
MacKAMEY, Rhodus ('30; '36), Asst. Engr. Plant Design, Gen. Engrg., Shell Oil Co., P. O. Box 728, Wilmington; *for mail,* P. O. Box 5001, Long Beach.
MAHONE, Francis D. ('31), 257 Roycroft Ave.
McENTEE, J. Robt. (J'36), Engrg. Trainee in Prod., Shell Oil Co., Hill & Obispo Sts.; *for mail,* 205 Quincy Ave.
MERRILL, Ernest N. (J'30), Oil Prod. Engr., Los Angeles Basin, Shell Oil Co., Box 290; *for mail,* Box 667, Route 1.
PHILO, Frank G. ('22), Supt. Steam Power Plants, So. Calif. Edison Co. Ltd., P. O. Box 771; *for mail,* 258½ Ximeno Ave.
WILLITS, Victor W., Jr. (J'36), Jr. Engr., Power Div., Procter & Gamble Mfg. Co., 1701 W. 7th St.; *for mail,* 228 Covina St.

LOS ANGELES, Los Angeles Section

AARON, Robt. H. (J'35), M. E., Los Angeles Dept. of Water & Power, 800 N. Spring St.; *for mail,* 238 S. Mariposa.
ARMSTRONG, Robt. Earl (J'35), Jr. Engr., Design Div. Metro. Water District of So. Calif., 306 W. 3rd St.; *for mail,* 824 W. 36th Pl.
BACON, Malcolm ('33), Asst. M. E., Metro. Water District of So. Calif., Earp; *for mail,* 5316 Lockhaven Ave., Los Angeles.
BAKESEF, Saml. ('23), Hyd. Engr., Layne & Bowler Corp., 900 Santa Fe Ave.; *for mail,* 4461 Crocker St.
BALL, Jas. Farrand ('27), Asst. Prof., Charge Aero., Los Angeles Jr. College, 855 N. Vermont Ave., Los Angeles; *for mail,* 537 N. Serrano Ave., Hollywood.
BALLOU, John McK. ('16; '21; '25), Partner, Ch. Engr., Linco Engrg. Co., Ltd., 2131 Barclay St.; *for mail,* 1071 Meadowbrook Ave.
BARNES, Harold H. ('28), Aircraft Inspc., N. Am. Aircraft Co.; *for mail,* 6216 Madden Ave.
BARRY, Wm. B. ('34; '35), 1863 Lucretia Ave.
BARUCH, Milton ('14; '21; '35), V. P., Herbert M. Baruch Corp., Ltd., 625 S. Olive St.
BEANFIELD, Byron F. (J'35), Engr., Charge Testing, Kobe, Inc., 3040 E. Slauson Ave., Huntington Park; *for mail,* 1876 Middleton Pl., Los Angeles.
BEANFIELD, Rufus McC. ('31), Cons. Engr., 615 Chamber of Commerce Bldg.; *for mail,* 1876 Middleton Pl.
BEATIE, Cecil E. ('12; '18; '19), Engr. & Contractor, 334 N. Normandie Ave.
BEESON, Frank M. ('28), Pres. Beeson Engrg. Co., Ltd., 2501 E. 52nd St.
BONHAM, Harry J. ('24), Pres., Bonham Iron Wks., Ltd., 1858 E. 64th St.
BRASCH, John ('31; '35), Designer, Warner Bros. First Natl. Studio, Burbank; *for mail,* 3055 Landa St., Los Angeles.
BRETT, Henry E. ('02), Cons. Engr., 4117 Griffin Ave.
BRITTAIN, John R. ('22), M. E., Charge Design, Los Angeles Ry. Corp., 401 E. 54th St.
BROBERG, Orrin R. (J'36), 2424 Berkeley Ave.
BROWN, Bruce F. ('21), Mgr. Southern Dist., Fibreboard Products, Inc., 4444 Pacific Blvd.
BROWN, Davis ('16), Cons. Engr., Rm. 516, 426 S. Spring St.
BROWN, J. Calvin ('28), Atty., Counsellor-at-Law, Rm. 804, 704 S. Spring St.
BUCKLEIN, Frank P. ('31), Propr., Bucklein Mfg. Co., 3765 San Rafael Ave.
BURCH, Kenyon C. (J'35), Draftsman, Engrg. Dept., Bethlehem Steel Co.; *for mail,* 715 S. Oxford Ave.
BUSSEY, John K. (J'35), 2518 W. 15th St.
CHAMBERLAIN, Leon H. ('25; '35), Dist. Mgr., Water Wks. Supply Co., 417 S. Hill St.
CHRISMAN, John L. (J'35), Draftsman, Union Oil Co. of Calif., Santa Fe Springs; *for mail,* 558 S. St. Andrews Pl., Los Angeles.
COBERLY, Clarence J. ('18; '35), Pres., Kobe, Inc., 3040 E. Slauson Ave., Huntington Park; *home address,* 325 S. McCadden Pl., Los Angeles.
COLLEY, C. T. ('26; '32; '35), Erec. Engr., Link Belt Co., 365 S. Anderson St.; *for mail,* 2923 S. Raymond.
COLLINS, Clifford H. (J'35), Engr., Maint. & Design, Hollywood Spring & Axle Co., 6009 Sunset Blvd.; *for mail,* 713 W. 41st Dr.
CORTELYOU, Curtis G. (J'36), M. E. Asst., Roy E. Hanson Co., 1924 Compton Ave.; *for mail,* 331 Branch St.
COSIN, Nicholas (J'17), Foreign Rep., Crane Export Corp., 4730—29th St., Long Island City, N. Y.; *for mail,* Natalina Arms Apts., 1833 W. 5th St., Los Angeles, Calif.
DAKIN, Richard Y. (J'27), Dept. of Meter Shops, So. Calif. Gas Co., 1700 Santa Fe Ave., Los Angeles; *for mail,* 1285 Oak Grove Ave., San Marino.
DAVIS, Lloyd E. (J'36), M. E., Am. Can Co., 4815 Sante Fe Ave.
DE FREMERY, Donald ('18; '26), Asst. Supt., Factories, Union Ice Co., 1315 E. 7th St.
DICKEY, Saml. J. ('26), V. P., Charge Mfg., Gen. Petroleum Corp. of Calif., 1003 Higgins Bldg.
DICKINSON, Reginald W. ('28; '35), Engr., Air Space Lath Co., 4011 Whiteside Ave.; *for mail,* 1318 W. 55th St.
DOOLITTLE, H. L. ('10; '16; F'36), Manager, '30-'33; Vice-President, '33-'35; Designing Engr., So. Calif. Edison Co., Ltd., 601 W. 5th St., P. O. Box 135.
DORN, Ralph W. ('34; '35), 1915 Beverly Blvd.
DOWNS, John W. ('29; '35), Pres., Downs Bros. Engrg. Co., 1726 E. Washington Blvd.; *for mail,* 3989 Normandie Ave.
DUNCAN, Geo. Walter ('21), Instr. Engrg., Los Angeles Jr. College, 855 Vermont Ave.; *for mail,* 1180 N. Berendo St.
DUNCAN, S. F. (J'31), Asst. Prof. M. E., Univ. of So. Calif., University Ave.

DUNN, Stephen M. ('26), Asst. M. E., Los Angeles Dept. of Water & Power, 207 S. Broadway; *for mail*, 1680 Hill Dr.
EATON, Geo. M. ('17), Sales Engr., Spang Chalfant & Co., Inc., 815 Transamerica Bldg.
EDWARDS, Albert B. ('30; '35), Asst. Dist. Maint. Engr., Div. of Highways, State of Calif., 808 Calif. State Bldg.
EGGLESTON, Herbert L. ('28), Mgr. Gas & Refining Depts., Gilmore Oil Co., 2423 E. 28th St., Los Angeles; *for mail*, 1017 Cumberland Rd., Glendale.
EILERSGAARD, Asger ('13), 2227 E. 37th St.
ELLINGWOOD, Elliot L. ('18), Cons. M. & E. E., 354 S. Spring St.
ELLIOTT, E. G. ('07), Mech. Designer, Los Angeles Union Passenger Terminal, 726 N. Alameda St.; *for mail*, 5033—4th Ave.
ERICKSON, Alfred L. ('25; '32; '35), Sales Engr., J. T. Thorpe, Inc., 941 E. 2nd St.
ESHELMAN, Clarence M. ('18), 4937 Hartwick St.
EYRE, Thos. T. ('15), Prof. M. E., Univ. of So. Calif., 3551 University Ave.
FARNSWORTH, Arthur J. ('23), Pat. Atty. & Counselor, 639 S. Spring St.
FARR, Morrill S. (J'35), Sales Engr., Consltd. Elec. & Mch. Co., 1000 Alhambra Ave.
FOURNIER, Thos. F. ('15; '35), Exec. V. P., Merchants Finance Corp., 621 S. Hope St.; *for mail*, 417 N. Oxford Ave.
FREE, Louis W. (J'26), Engrg. Dept., Gay Engrg. Corp. of Calif., 2650 Santa Fe Ave.
FREEMAN, Arthur B. (J'33), 1031 W. 97th St.
GALLAGHER, John S. ('21; '28), 1037 Burnside Ave.
GANNON, Jesse ('20; '35), Engr., Charge Design, Harvey Mch. Co., 1333 S. Los Angeles St., Los Angeles; *for mail*, 4301 Jackson Ave., Culver City.
GARDNER, Robt. (J'36), 533 W. Cherokee Ave.
GEORGE, V. C. ('31), Instr. Physics, Los Angeles Jr. College, 855 N. Vermont Ave.
GILMORE, Albert Munro (J'29), Vice-Chairman, Allied Engrs., 745 S. Union Ave.
GILMORE, Gordon M. ('31), Sales Engr., Los Angeles Steel Casting Co., 2444 S. Alameda St.
GOSSMAN, Angelo L. ('21; '25; '35), V. P., Gen. Mgr., Dicalite Co., 756 S. Broadway.
GREENWOOD, Oral D. (J'35), Engr., G. E. Air Conditioning Co., 1510 S. Los Angeles St.; *for mail*, 3839 Arlington St.
GREGORY, Jas. N. (J'35), Engr., Field Engrg. Dept., Shell Oil Co., 1008 W. 6th St., Los Angeles; *for mail*, 2785 Carlaris Rd., San Marino.
GRIFFITH, Leigh M. ('15; '28), Cons. M. E., 8000 Blackburn Ave.
HACKSTAFF, John D. ('01; '17), Cons. Engr., 520 Chapman Bldg.; *for mail*, 1661 S. Oxford Ave.
HAGLUND, A. G. ('23; '35), Wks. Mgr., Axelson Mfg. Co., P. O. Box 710, Vernon Sta., Los Angeles; *for mail*, 2516 Live Oak St., Huntington Park.
HALLIWELL, Arthur ('24; '35), Kinney Iron Wks., 2525 E. 49th St.
HARP, Thos. Lynn (J'36), 624 W. 41st Dr.
HARRIS, Ford W. ('13), Head, Harris, Kiech, Foster & Harris, 471 Chamber of Commerce Bldg.
HARRIS, Phil B. ('31), V. P., Gen. Mgr., Los Angeles Ry. Corp., Rm. 807, 1060 S. Broadway.
HEDDELL, Douglas ('23; '33; '35), Jr. M. E., Los Angeles Dept. of Water & Power, 410 Ducommun St.
HEDRICK, Earle Raymond ('18), Prof. Math., Univ. of Calif. at Los Angeles, 405 Hilgard Ave.
HELMICK, Walter E. ('20; '24; '35), *Student Award*, '19; Engr., Prod. Dept., Shell Oil Co., 1008 W. 6th St., Los Angeles; *for mail*, 415 N. Valencia St., Alhambra.
HENGSTLER, John L. (J'31), Air Conditioning Engr., West. Air & Refrig., Inc., 1234 S. Grand Ave.; *for mail*, 2315 So. Flower St.
HICKS, Robt. E. ('24; '30), 10766 Wellworth Ave., W. Los Angeles.
HIRTH, E. F. (J'35), Mech. Draftsman, Los Angeles Dept. of Water & Power, 207 S. Broadway; *for mail*, 2322 Nella Vista.
HOFFMAN, J. Roy ('16; '26), Engr., V. P., Smith-Booth-Usher Co., 228 Central Ave.
HOLMES, Jas. T. ('26), Pres., Charge M. E. Design, Holmes & Narver, Inc., 639 S. Spring St., Los Angeles; *for mail*, 521 N. Bedford Dr., Beverly Hills.
HOOPES, A. G. ('33), Ch. Engr., Lankershim Estate Corp., 126 W. 3rd St.; *for mail*, 3470 Berry Dr., N. Hollywood.
HOUGHTON, Harry S. ('18; '25), Gen. Mgr., Witt Ice & Gas Co., 652 E. 61st St.
HOXIE, Geo. L. ('93; '04), Cons. Engr., Edison Bldg.
INGHAM, Herbert S. (J'31), Ch. Engr., Harder & Ingham Mch. Co., 4048 Whiteside Ave., Los Angeles; *for mail*, 1801 S. Date Ave., Alhambra.
JACOBS, W. Morton (J'29), Gen. Supt., Sales, So. Calif. Gas. Co., 950 S. Broadway, Los Angeles; *for mail*, 871 Matilija Rd., Glendale.
JENSEN, Scott ('20; '27), Power Engr., Charge Power Plant, Firestone Tire & Rubber Co., 2525 Firestone Blvd., Los Angeles; *for mail*, 2524 Walnut St., Huntington Park.
JOHNSON, Jos. Benj. ('20), M. E., Design & Constr. of Plants, Metro. Water Dist. of So. Calif., 306 W. 3rd St., Los Angeles; *for mail*, 643 Geneva St., Glendale.
JOSEPH, Paul A. (J'35), Steel Inspr., Jr. Engr., Metro. Water Dist. of So. Calif., 306 W. 3rd St.; *for mail*, 932 S. Burlington Ave.
KATOW, M. Smoot (J'36), 2630 E. 1st St.
KEESE, R. B. ('19), Asst. M. E., Los Angeles Bur. of Power & Light, 207 S. Broadway; *for mail*, 1009 N. Coronado St.
KERR, Chas. V. ('92), Cons. M. E., 418 Ulysses St.
KING, Chas. B. ('12), Retired; 807 S. Windsor Blvd.
KING, Peter M. ('19; '35), Designing Engr., Gen. Petroleum Corp. of Calif., 2525 E. 37th St.
KINGMAN, Douglas G. (J'29), Asst. Prod. Engr., Gen. Petroleum Corp. of Calif., 2525 E. 37th St., Los Angeles; *for mail*, 715 N. Olive St., Alhambra.
KIRBY, William K. ('19; '23), Engr., Sales Promotion, Tunnell, Wood & Neilan, Inc., 2440 Enterprise St.
KISHBAUGH, Theo. L. (J'27), Sales Engr., Earle M. Jorgensen Co., 10510 S. Alameda St., Los Angeles; *for mail*, 545 N. Sunnyslope, Pasadena.
KUPFER, Robert C. (J'35), M. E., Frequency, Los Angeles Dept. of Water & Power; *for mail*, 2125 Crenshaw Blvd.
KURILOFF, Arthur H. (J'34), c/o Judge Pacht, 277 So. Irving Blvd.
LABARRE, Robt. V. ('23), Cons. Engr., 284 Chamber of Commerce Bldg.
LANGE, H. B. ('30), Partner, Lange & Miller, 621 S. Hope St.
LEDEEN, Hyman ('19; '22; '28), Pres. Engrg. Products Co., 747 Warehouse St.
LEE, Smith ('31), Propr., Smith Lee, Cons. & Designing Engrg., 704 S. Spring St.
LEEDS, Jacob H. (A'22), V. P., Charge Sales & Engrg., Robt. M. Hartwell Co., Inc., 353 E. 2nd St.
LEHMANN, Matt, Jr. (J'32), Ch. Engr., Charge Design & Installation, Stand. Engrg. Sales Co., 413 S. La Brea Ave.; *for mail*, 6636 Drexel Ave.
LIENESCH, Chas. F. ('29), Tech. Rep., Liason Sales, Mfg. & Research Depts., Union Oil Co. of Calif., 617 W. 7th St.; *for mail*, 1793 Campus Rd.
LINDSEY, Roy, Jr. (J'34), Sales Engr., Automatic Screw Mch. Co., 800 E. Gage Ave., Los Angeles; *for mail*, 809 N. Spaulding Ave., Hollywood.
LIPP, Elmer L. ('32; '35), Gen. Mgr., Gen. Mch. Wks., 3017 San Fernando Rd.
LOCKE, Emanuel D. ('29; '35), c/o Locke Motors, 900 E. 7th St.
LUPTON, Watson Walker (J'36), Jr. Prod. Engr., Shell Oil Co., 1008 W. 6th St., Los Angeles; *for mail*, 2205 B St., Bakersfield.
LYONS, Daniel A. ('20; '28), Ch. M. E., Consltd. Steel Corp., P. O. Box 1348, Arcade Sta.
MANGE, L. Bender (J'36), Jr. Engrg. Aide, Survey Party, Div. Highways, Dept. Pub. Wks., State of Calif., 808 State Bldg., Civic Center, Los Angeles; *for mail*, 51 Whitney, Los Gatos.
MARTIN, Jesse C., Jr. ('19), Cons. Engr., Combustion & Refractories, 1325 Miller Dr.
MASON, Wendell E. (J'21), Asst. Prof., Univ. of Calif. at Los Angeles, 405 Hilgard Ave., Los Angeles; *for mail*, 220 S. Swall Dr., Beverly Hills.
MAYER, Richard L. (J'35), M. E. Drafting, Consltd. Steel Corp., Ltd., Box 1348, Arcade Sta.; *for mail*, 123½ S. Flores Ave.
McNEILL, Neil S. (J'36), Draftsman, Pioneer-Flintkote Co., 55th & Alameda; *for mail*, 621½ W. 45th St.
MEARS, Edmund (J'36), 851½ Crenshaw Blvd.
MEILI, Gottfried ('35), Ch. Shop Instr., M. E., Hemphill Diesel Engrg. Sch., 2121 San Fernando Rd.
MENDENHALL, Earl ('28; '31), V. P., Gen. Mgr., Sterling Elec. Motors, Inc., 5401 Telegraph Rd.; *for mail*, 7615 La Salle Ave.
MERRILL, David R. ('35), Mgr. Research, Union Oil Co. of Calif., 617 W. 7th St., Los Angeles; *for mail*, 4245 Chestnut Ave., Long Beach.
METCALF, Lester G. ('20; '30), Mgr. Refineries, Union Oil Co. of Calif., 617 W. 7th St.
MEYER, Arnold I. (J'36), Salesman, Meyer Mchy. Co., 1939 Santa Fe Ave.
MILLER, Wm. G., 3d ('28; '35; '35), Asst. to Gen. Mgr., Witt Ice & Gas Co., 652 E. 61 St.
MILLINGER, Wm. A. F. ('18; '19; '30), Cons. Engr. & V. P., Charge Tours, Engrg. Project Services-Tours Internatl., 1864 North Ave. 51.
MOCK, Richard M. (J'27), Rep. Fokker Aircraft Co., Holland, Fokker Office, c/o Douglas Aircraft Co., Santa Monica; *for mail*, 323 N. Mansfield Ave., Los Angeles.
MORGAN, Jas. L. ('18; '35), Sales Engr., Northwest. Barb Wire Co., 1615 E. 7th St.; *for mail*, 3027½ Berkeley Ave.
MOULTON, Morgan V. ('24), Mgr., Transportation Dept., Sunset Oil Co., 610 S. Main St.
MYERS, Thos. G. ('32), V. P., Ch. Engr., U. S. Elec. Motors, Inc., 200 E. Slauson Ave.
NAGEL, Carl (J'31), Plant Engr., Continental Can Co., Inc., 3820 Pacific Ave.; *for mail*, 1341 Amalia Ave.
NANCE, G. Russell (J'36), 2321 Buckingham Rd.
NICOLSON, Garth F. (J'35), Engr., Oil Tool Design, Byron Jackson Co., P. O. Box 1307, Arcade Sta.
NOLTIMIER, Frederick H. (J'32), Gen. Petroleum Corp. of Calif., 108 W. 2nd St., Los Angeles; *for mail*, 3405 Grand Ave., Huntington Park.
NORTHRUP, M. G. (J'36), 839 W. 43rd Pl.
OGAWA, Yoshio (J'27), Owner, Yoshio Ogawa, Product Engr., 3516 Raymond Ave.
PAECH, Erik G. ('30; '35), Engr. & Mgr., Charge Mfg., Braun Corp., 2260 E. 15th St.
PATINGA, Cornelio B. (J'35), 123 S. Main St.
PATON, Wm. R. (J'31), Ch. Engr. of Instr., Diesel Engrg. Sch. of Los Angeles, 1100 S. Flower St.; *for mail*, 2432 West Ave. 30.
PAXTON, Chas. H. ('24), Assoc., Univ. of Calif. at Los Angeles, 405 Hilgard Ave.; *for mail*, 4201 Dalton Ave.
PECK, Russell LeB. (J'32), Mech. Draftsman, Designer, Frequency Change Sec., Los Angeles Bur. of Power & Light, 2nd & Broadway; *for mail*, P. O. Box 5422, Metropolitan Sta.
PEGG, Albert O. ('26), Suptg. Engr., Union Oil Co. of Calif., 7th & Hope Sts.
PERRY, Harry M. ('20; '29), Mfr., Beltslaker Idlers, 737 N. Spring St.
PLEUKHARP, Claude W. ('22; '35), 10642 Esther Ave.
PURCELL, John P. (J'35), Engr. in Sales, Columbia Steel Co., 2087 E. Slauson Ave.
QUICK, R. T. (J'32), Gen. Mgr., Welded Fabrication Co., 6009 Wilmington Ave.
RAY, Albert Allen (J'35), Engr., Devel. Dept., Union Oil Co. of Calif., 7th & Hope Sts.
RAY, David H. ('04; '11), Life Member; Engrg. Examiner, Civil Serv., City of Los Angeles, Rm. 1206, City Hall, Los Angeles; *for mail*, Arcadia.
REED, Ralph J. ('25), Cons. Engr., 905 Edison Bldg., 601 W. 5th St.
REPATH, Chas. H. ('91), Retired, Repath Mfg. Co., 649 E. 61st St., Los Angeles; *for mail*, 331 Mt. Holyoke Ave., Pacific Palisades.
RICHARDS, H. F. (J'35), Research Engr., Soil Conservation Serv., U. S. Dept. Agri., Calif. Inst. of Tech., Pasadena; *for mail*, 771 E. 14th St., Los Angeles.
RICHARDSON, L. F. (J'30), M. E., Sales & Serv., Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio; *for mail*, 1245 W. 49th St., Los Angeles, Calif.
ROBERTSON, Robt. R. ('19), Engr. of Constr., Los Angeles Bur. of Power and Light, 207 S. Broadway; *for mail*, 134 N. Ardmore Ave.
ROBINSON, Robt. Rex ('23; '30), Cons. Engr., 429 Alpine St.; *for mail*, 2402 Victoria Ave.
ROLLOW, J. Grady ('15; '22), Ch. Engr., Los Angeles Gas & Elec. Corp., 810 S. Flower St.
ROSS, Thurston Howard ('26), Cons. Engr., 3465 Knollcrest Ave.
ROWSE, Wm. C. ('12; '16), Engr. of Preliminary Investigations, Los Angeles Dept. of Water & Power, 207 S. Broadway; *for mail*, 5264 College View Ave., Eagle Rock.
SALLOWS, Edmund (J'33), 2727 Alsace Ave.
SCHMIDT, Albert G. ('21), Rep., Harnischleger Sales Corp., Milwaukee, Wis.; *for mail*, 2029 Santa Fe Ave., Los Angeles, Calif.
SCHMIDT, Arthur A. ('14; '21), M. E., West. Precipitation Co., 1016 W. 9th St.; *for mail*, 2201 Hill Dr., Eagle Rock.
SCHOENKY, Otto B. ('14), Supt. of Motive Power, So. Pacific Co., 1800 Alhambra Ave.
SCHULTZ, Wm. F. (J'32), Maint. Foreman, Needles Ice Plant, Atchison, Topeka & Santa Fe Ry. Co.; *for mail*, 1254 W. 70th St.
SEARS, Harold R. ('14; '21; '35), 941 S. Bonnie Brae St.
SEDERHOLM, E. T. ('89), Cons. Engr., Brodgex Co., 2nd St., Pomona; *for mail*, 118 S. Normandie Ave., Los Angeles.
SELSER, Thos. W. ('11; '14; '16), Engr., Charge Sales, Macco Constr. Co., 815 Paramount, Clearwater; *for mail*, 2341 Fargo St., Los Angeles.
SENSEMAN, Wm. B. ('27), West. Mgr., Charge Sales & Serv., Raymond Bros. Impact Pulverizer Co., 406 S. Main St.
SHADE, Nevin R. ('19; '24; '35), Asst. Engr., Gen. Petroleum Corp. of Calif., Higgins Bldg.; *for mail*, 1833 E. 70th St.
SHATTUCK, C. H. ('14; '20; '35), Engr., Chem. Processes Co., 1355 E. 17th St., Los Angeles; *for mail*, 1585 Lombardy Rd., Pasadena.
SHELTON, Wm. A. ('12; '25; '35), Jr. M. E., Los Angeles Bur. of Power & Light, Rm. 410, 311 S. Spring St.; *for mail*, 1466 W. 50th St.
SHETTEL, W. Roy ('25), Constr. Engr., Los Angeles Gas & Elec. Corp., Metropolitan Sta., Box 6200.

SIMPSON, Thos. F. ('23; '35), Mech. Supt., Ambassador Hotel, 3400 Wilshire Blvd.; *for mail*, 5420 Delaware St.
SIMSON, Jerome ('22; '30; '35), M. E., Frequency Change Sec., Los Angeles Bur. of Power & Light, 800 N. Spring St.; *for mail*, 221 N. New Hampshire.
SINGER, Sidney C. ('09; '16; '21), Mgr., San Fernando Valley Div., So. Calif. Gas Co.; 950 S. Broadway, Los Angeles; *for mail*, 530 N. Central Ave., Glendale.
SNYDER, Lewis L. ('23; '35), Propr., Consltd. Elec. & Mch. Co., 1000 Alhambra Ave.; *for mail*, 1476 W. 46th St.
SPARLING, Ray C. (J'34), Calif. Sales Rep., R. W. Sparling, 945 N. Main St.
SPRADO, Ralph ('00), Life Member; Cons. Engr., Sprado Engrg. Co., 414 Bryson Block.
STROMGREN, Chas. D. ('18; '35), Mgr., Owner, Perfo Piston Ring Co., also Chas. D. Stromgren Co., 937 W. 12th St.
SUTER, John H. ('14), Suter Gas & Diesel Eng. Co., 2441 Hunter St.
SWANTON, Harold R. (J'27), Indus. Sales Mgr. & Asst. Secy., Precision Bearings, Inc. (Div. of Norma-Hoffmann Bearings Corp.), 1706 S. Grand Ave.
TAYLOR, Reese H. ('25; '31; '35), V. P., Consltd. Steel Corp., Ltd., P. O. Box 1348, Arcade Sta.
THIEME, R. B. (A'30), Pac. Coast Mgr., Internatl. Filter Co., 2309 E. 8th St.
THOMPSON, Wilfred Gregg ('26; '35; '35), Products Engr., Richfield Oil Co., 1835 E. Washington Blvd.
TIERNEY, Jas. E. ('22; '35), Pres., Allube Corp., 1726 Standard Ave., Glendale; *for mail*, 3160 W. 11th St., Los Angeles.
UGRIN, Nick (J'35), M. E. & Draftsman, Union Oil Co. of Calif., 617 W. 7th St., Los Angeles; *for mail*, P. O. Box 661, San Luis Obispo.
VAIL, David P. ('20; '27), Mgr., C. C. Moore & Co., Rm. 811, 555 S. Flower St.
VAIL, Harold P. ('21; '27), Engr., Distribution Dept., Metro. Water Dist. of So. Calif., 306 W. 3rd St., Los Angeles; *for mail*, 1316 Graynold Ave., Glendale.
VON KORIES, Otto ('23), Pres. & Gen. Mgr., Cycle Unit Engrg. Corp.; *for mail*, 1617½ Echo Park Ave.
WADE, Franklin S. ('18), Pres., Gen. Mgr., So. Counties Gas Co., Rm. 609, 810 S. Flower St.
WALTON, Sylvan Brooks (J'35), Accountant, Goddard Jackson Co., 1400 Santa Fe Ave.; *for mail*, 2153 W. 82nd St.
WARD, Lester D. (J'34), Concrete Inspr., Metro. Water Dist. of So. Calif., 306 W. 3rd St.
WARDEN, Guy L. ('16; '23; '29), Power & Indus. Equip., 114 W. 17th St.
WARNER, A. L. D. ('33), Pres., Warner Sales, Ltd., Los Angeles; *for mail*, 728 N. Roxbury Dr., Beverly Hills.
WASHBURN, Morgan, Jr. ('23; '30), Sales Engrg., 1341 S. Hope St.
WATSON, Thos. A. ('25; '35), Assoc. & Chmn., Cent. Mch. Shop, Univ. of Calif. at Los Angeles, 405 Hilgard Ave.; *for mail*, 740 Hyperion Ave.
WEISMANN, Victor (J'35), M. E., Dept. Maint., Shell Refinery, Shell Oil Co., Wilmington; *for mail*, 629 W. Santa Barbara, Los Angeles.
WELLS, Albert W. ('18; '32; '35), Inspr., Engrg. Dept., Los Angeles Ry. Corp., 1060 S. Broadway, Los Angeles; *for mail*, 1093 Avoca Ave., Pasadena.
WHITCOMB, Leroy A. ('29), Whitfi Lab., P. O. Box 1325, Arcade Sta.
WILSON, Chas. E. ('12), V. P. Sales, Worthington Pump & Mchy. Corp., 510 W. 6 St., Los Angeles; *for mail*, 610 N. Sierra Dr., Beverly Hills.
WOLFE, Richard C. ('32; '35), Owner, Specialty Sales, 831 S. Olive St.
ZUBLIN, John A. ('30), Pres., Gen. Mgr., Universal Engrg. Co., 2369 E. 51st St.
ZUCKERBERG, Harry (J'35), Stress Engr., Lockheed Aircraft Corp., Burbank; *for mail*, 2825 West Blvd., Los Angeles.

LOS GATOS, San Francisco Section

LESLIE, Richard B. ('35), Draftsman, Anderson-Barngrover Div., Food Mchy. Corp., W. Julian St., San Jose; *for mail*, Glen Una Dr., Los Gatos.
PAGE, Stanley H. ('29), Life Member; Box 404.

LOS NIETOS, Los Angeles Section

SPRINGER, Edwin Kent (J'36), Plant Engr., Charge Design & Exper. Wk., Fluid Packed Pump Co., P. O. Box 64, Los Nietos; *for mail*, 1128 W. 50th St., Los Angeles.

MANTECA, San Francisco Section

WRIGHT, Jas. C. (J'36), Student Wk., Spreckels Sugar Co.

MARE ISLAND, San Francisco Section

CALIFRO, Ernest ('34; '35), Engrg. Dept., Machy. Div., Navy Yard, Mare Island; *for mail*, 1811 Brush St., Oakland.
OERTEL, Gustave (J'33), Loco. Engr., Naval Ammunition Depot, Navy Yard, Mare Island; *for mail*, 1042 Napa St., Vallejo.

MARTINEZ, San Francisco Section

CAUDEL, Fred H. (J'34), Research Engr., Shell Oil Co.; *for mail*, 1330 Warren St.
LINDEKE, Hans ('27; '35), Charge Edelcanu Plant, Shell Oil Co.; *for mail*, Box 431.
RONAN, John T. (J'34), Research Engr., Shell Oil Co.; *for mail*, 1935 Pacheco Blvd.

MARYSVILLE, San Francisco Section

COOK, Willis D. ('21), Supt. Equip., Shop 3, Div. Highways, Dept. Pub. Wks., State of Calif.; *for mail*, 818—13th St.

MILL VALLEY, San Francisco Section

CHAPIN, Geo. W. (J'36), 78 King St.

MONROVIA, Los Angeles Section

ALEXANDER, Wm. W. ('24; '32; '35), 710 E. Palm Ave.
BISSELL, Geo. W. ('90; '99), P. O. Box 116.
NEEDHAM, Wm. H. ('24; '29), Retired; 340 Highland Pl.

MONTROSE, Los Angeles Section

BURKE, Henry E. (J'28), 2450 Floreneita.
PALMER, E. Stanton (J'34), Foreman, E. C. W. Div., U. S. Bur. of Reclamation; *for mail*, 445 Main St.

MORRO BAY, Los Angeles Section

KOUNTZ, Carl M. (J'24), Box 216.

MOUNTAIN VIEW, San Francisco Section

LEWIS, Richard Campbell ('34), Santa Claire Co.
SEMINO, Angelo F. ('26; '35), Treas., Indus. Engrs., Inc., 819A E. 59th St., Los Angeles; *for mail*, Route 1, Box 149, Mountain View.

NAPA, San Francisco Section

REED, J. R. (J'35), 1441 A St.

OAKLAND, San Francisco Section

ADAMS, C. S. ('16; '25), 2417 Foothill Blvd.
AMNEUS, Nils A. ('14), Mch. Designer, United Iron Wks.; *for mail*, 707—63rd St.
ANDERSON, Kenneth B. (J'24), Property Mgr., Coast Indus. Gas Co., Rm. 406, 225 Bush St., San Francisco; *home address*, 5401 Belgrave Pl., Oakland.
AVERY, Harold Tolman ('35), Ch. Engr., Marchant Calculating Mch. Co., 1475 Powell St.
BARNETT, Jas. Morris (J'30), Atlas Imperial Diesel Eng. Co., Foot of 19th Ave., Oakland; *for mail*, 554 Santa Barbara Rd., Berkeley.
BEAN, Theron W. ('31; '35), Apt. 21, 832 Erie St.
BLOOM, K. E. (J'33), 5318 Bond St.
COX, C. Gordon ('17), 408 Euclid Ave.
FERRIS, Ervie A., Jr. (J'30), Engr., Pacific Pipe Co.; *for mail*, 2621—14th Ave.
HARRISON, Geo. G. ('34), Ch. Engr., S. T. Johnson Co., 940 Arlington St., Oakland; *for mail*, 1624 La Loma, Berkeley.
HOWARD, Henry S. ('33), Cons. Engr., 95 Market St.
ILUMIN, Mamerto V. (J'36), 596—19th St.
KIMBALL, Robt. Schaeffer (J'36), Atlas Imperial Diesel Eng. Co., Oakland; *for mail*, 120 Lorton Ave., Burlingame.
LARSON, John A. (J'36), Jr. Salesman & Serv. Man, Am. Radiator Co., 4th & Townsend Sts., San Francisco; *for mail*, 5550 Kales Ave., Oakland.
LEMERY, Jack W. R. (J'35), Asst. Plant Engr., Rheem Mfg. Co., Chesley Ave. & S. P. Tracks, Richmond; *for mail*, 77 Glen Ave., Oakland.
LONDON, A. L. (J'35), Engr., Constr. Wk., Stand. Oil Co. of Calif., Bush St., San Francisco; *for mail*, 5409 Thomas St., Oakland.
LONGLEY, Francis B. ('16), Tech. Adviser, Calif. S. R. A., 86—3rd St., San Francisco; *for mail*, 3623 Grand Ave., Oakland.
MACLEAN, W. Wallace ('25; '28; '35), M. E., Aladdin Htg. Corp., 5107 Broadway.
MADDEN, John A. (J'33), Machinist, Navy Yard, Mare Island, Vallejo; *for mail*, 1524—35th Ave., Oakland.
McDONOUGH, P. W. ('21; '31), Mgr. & Sole Owner, Boiler Tank & Pipe Co., 800—75th Ave.
McKINLAY, Jas. ('22), 5741 Buena Vista Ave.
MORRILL, T. Leonard Jr. (J'32), Business Asst., Alcatraz Repair Co., 429 Alcatraz Ave.; *for mail*, 6435 Hillegass Ave.
MURRAY, Edwin D. ('32), Cons. Engr., 5850 Birch Court.
RICHARDS, Geo. Burge (J'35), Field Engr., Ralph N. Brodie Co., Lowell & 61st St.
ROSEN, Carl Geo. A. ('16; '21; '35), Engr., Charge Diesel Devel., Caterpillar Tractor Co., San Leandro; *for mail*, 3044—57th Ave., Oakland.
ROSS, Frank E. ('13), Retired; 3014 Coolidge Ave.
ROWLEY, Ridgway L. ('10; '16; '22), Secy., Dir., Ch. Engr., Johnson & Higgins of Calif., 311 California St., San Francisco; *for mail*, 645 Valle Vista Ave., Oakland.
RUDOLF, Geo. A. (J'33), Engr., Design, Fageol Truck & Coach Co., 107th & Hollywood Blvd.; *for mail*, 3743 Emerson St.
SCHULZ, L. E. ('17), Project Engr., 404 Mayfair Apts., 400 Perkins St.
SEAGREN, John ('26; '35), Ch. Engr., Atlas Imperial Diesel Eng. Co., 1000—19th Ave.
SHERWOOD, Herbert L. (J'31), Jr. Engr., Pac. Gas & Elec. Co., 1625 Clay St., Oakland; *for mail*, 1532 Beverly Pl., Berkeley.
SMITH, Keith V. (J'35), 3044—55th Ave.
SOMERVILLE, Geo. N. ('17; '35), Dir., Sales Mgr., Atlas Imperial Diesel Eng. Co., 1000—19th Ave., Oakland; *for mail*, 1240 Carlotta Ave., Berkeley.
SOMMARSTROM, Clifford Edw. (J'36), 627 Vernon St.
STEWART, H. P. (J'34), Estimator & Sales Engr., Bethlehem Shipbldg. Corp., Ltd., San Francisco; *for mail*, 5280 Belvedere St., Oakland.
STOUT, V. A. ('24), Sales Mgr., F. A. B. Mfg. Co., Inc., 67th & Vallejo Sts., Oakland; *for mail*, 632 San Luis Rd., Berkeley.

OILFIELDS, San Francisco Section

PURDY, Donald F. ('22; '25; '33), Field Supt., Shell Oil Co., Oilfields, Fresno Co.

ONTARIO, Los Angeles Section

KRIEGH, Geo. W. (J'35), Route 3.
WRIGHT, Jas. A. ('20; '21), P. O. Box 25.

PACIFIC PALISADES, Los Angeles Section

JOSEPHO, Anatol M. ('29), 2100 Rustic Canyon.
YOUNG, John W. (J'28), 1101 Embury St.

PALM SPRINGS, Los Angeles Section

MASON, Wm. A. (J'32), *Postgraduate Student Award*, '32; Box 637.

PALO ALTO, San Francisco Section

CONLEY, John W. (J'35), Box 650, Alta Mesa Rd.
HOOVER, Hon. Herbert (H'25).
WOOD, Dennistoun ('14), Engr. of Tests, So. Pac. Co., 65 Market St., San Francisco; *for mail*, 809 Lincoln Ave., Palo Alto.

PASADENA, Los Angeles Section

BAKER, Ralph D. (J'27), 138 S. Holliston Ave.
BURTON, W. Dean ('14), Engr., Astrophysical Observatory, Calif. Inst. of Tech.; *for mail*, 717 E. California St.
CLAPP, W. Howard ('14), Prof. Mch. Design, Calif. Inst. of Tech.
CLARK, Donald S. (J'30), Instr., M. E., Calif. Inst. of Tech., 1201 E. California St.
COTTON, Geo. G. ('02), Retired; 1324 N. Marengo Ave.
CRATER, Myron L. (J'33), Oper. Engr., Pasadena Light & Power Dept., City Hall; *for mail*, 1537 Corson St.
DAUGHERTY, Robt. L. ('19; F'36), Manager, '25-'28; Vice-President, '28-'30; Prof. M. E., Calif. Inst. of Tech.
FLEMING, Thos., Jr. ('19), Cons. Engr., Century Bldg., Pittsburgh, Pa.; *for mail*, 1541 Lombardy Rd., Pasadena, Calif.
GARRETT, John A. ('18), Sales Engr., Fairbanks, Morse & Co., 2401 Santa Fe Ave., Los Angeles; *for mail*, 1422 Wayne Ave., S. Pasadena.
GATE, Paul A. ('26; '35), Draftsman, Astrophysical Observatory, Calif. Inst. of Tech., Pasadena; *for mail*, 2905 Allesandro St., Los Angeles.
GETZMAN, Edwin M. (J'36), Sales Rep., So. Calif. Gas Co., 950 Broadway, Los Angeles; *for mail*, 1218 Spruce St., S. Pasadena.
KNAPP, Robt. T. (J'21), Asst. Prof., M. E. Dept., Calif. Inst. of Tech., Pasadena; *for mail*, 2526 N. Roosevelt, Altadena.
KRATZ, R. P. ('21; '35), Bldg. Constr., Parker & Gamble Ltd., 29 S. Euclid Ave., Pasadena; *for mail*, 1960 Escarpa Dr., Los Angeles.
MILLIKAN, Clark B. ('31; '35), Assoc. Prof. Aero., Calif. Inst. of Tech., 1201 E. California St.
MILLIKAN, Robt. A. (Non-Member), *A.S.M.E. Medallist*, '26; Calif. Inst. of Tech.
OAKS, Robt. M. (J'32), 451 S. Virginia Ave.
PEASE, Francis G. ('15), Astronomer, Mt. Wilson Observatory, 813 Santa Barbara St.
PROSSER, Jos. G. ('91; '98), 865 S. Grand Ave.
ROCKEFELLER, W. C. (J'33), Teaching Asst., Calif. Inst. of Tech.

SERRELL, Peter Van Horne (J'36), Student & Teaching Asst., Calif. Inst. of Tech.
SPAULDING, Harold S. (J'29), Div. Engr., C. F. Braun & Co., Alhambra; *home address*, 690 S. Euclid Ave., Pasadena.
STACY, Parker A., Jr. (J'36), 490 E. California St.
THOMAS, Carl C. ('08), Manager, '20-'22; V. P., Dwight P. Robinson & Co., Inc., 611 Architects Bldg., Los Angeles; *for mail*, 165 Linda Vista Ave., Pasadena.
von KARMAN, Theodor ('31), Dir. of Guggenheim Aero. Lab., Calif. Inst. of Tech.
von SCHLEGELL, Fred'k ('15), Pres., United Linen Supply Co., 888 Arroyo Blvd.
WATSON, Ralph M. (J'30), Teaching Fellow, Calif. Inst. of Tech., 1201 E. California; *for mail*, 191 S. Berkeley.
WILSON, H. Dalzell ('03; '12), 1011 Oak Grove Ave.
WRIGHT, Ernest N. ('90), 619 Drexel Pl.

PIEDMONT, San Francisco Section

BROBECK, Wm. M. (J'31), 400 Hillside Ave.
GEORGE, Francis X., Jr. (J'34), Licensed Mar. Engr., Charge Opera., Maint., various S. S. Cos., San Francisco; *for mail*, 962 Rose Ave., Piedmont.
SHAWK, Harry A. ('29), Ch. Lub. Engr., Associated Oil Co., 79 New Montgomery St. San Francisco; *for mail*, 111 Greenbank Ave., Piedmont.
SWEETLAND, Ernest J. ('17), Chmn., Bd. of Dirs., Oliver United Filters, Inc., 351 California St., San Francisco; *for mail*, 11 Glen Alpine Rd., Piedmont.
WINCHESTER, Douglas L. (J'32), 180 Oak Rd.

PITTSBURG, San Francisco Section

BEJARANO, Julio G. (J'26), M. E., Charge Opera., Maint. & Design, Shell Chem. Co.
DISHINGTON, Herman (J'35), Jr. Engr., Charge Carbon Black Plant, Shell Chem. Co.
FLINK, Axel A. (J'35), Asst. Indus. Engr., Columbia Steel Co.; *for mail*, 405 Los Medanos Hotel.
KENNEY, Jas. T. ('27; '35; '35), Engr., Charge Design, Great West. Electro-Chem. Co., Pittsburg; *for mail*, 517—12th St., Antioch.
MacKENZIE, John A. ('31), Shell Chem. Co.; *for mail*, Pittsburg Apts. 7.
PYZEL, Ewald (J'26), Supt., Shell Chem. Co., Box 875.
WORK, Raymond P. (J'35), Gas Measurement Engr., Coast Indus. Gas. Co., Box 70.

POINT LOMA, Los Angeles Section

TYBERG, Oluf ('98).

POMONA, Los Angeles Section

JANSSEN, Earl (J'36), Engr., Sales Engrg., Pomona Pump Co.; *for mail*, 274 Palm Pl.

REDLANDS, Los Angeles Section

SERRELL, John A. ('95), 821 Crescent Ave. C.

REDWOOD CITY, San Francisco Section

SHIELDS, Ralph I. ('32), Asst. Supt., Pac. Portland Cement Co., Redwood City; *for mail*, 1020 Rosewood Ave., San Carlos.

RICHMOND, San Francisco Section

COLE, Jas. H. ('28; '34; '35), Engr., Stand. Oil Co. of Calif.; *for mail*, 461 Dimm St.
GAY, Joe A. (J'35), Engr., Stand. Oil Co. of Calif., Richmond Refinery, Richmond; *for mail*, 1439 Liberty St., El Cerrito.
GERLING, Arthur (J'30), Asst. Power Engr., Stand. Oil Co. of Calif., Richmond; *for mail*, 1037 Pomona Ave., Albany.
HALLORAN, Ralph A. ('18; '35), Mgr., Research & Devel. Dept., Stand. Oil Co. of Calif.
LAINE, Leo (J'35), Jr. Engr., Stand. Oil Co. of Calif., Richmond; *for mail*, 1810 Euclid Ave., Berkeley.
MacPHERSON, Gordon R. (J'32), Jr. Engr., Stand. Oil Co. of Calif., Richmond; *for mail*, 225 Bush St., San Francisco.
MATTESON, Robt. (J'30), Test Engr., Stand. Oil Co. of Calif., Richmond; *for mail*, 2233 Marin Ave., Berkeley.
RIMOV, Stephen (J'29), M. E., Stand. Oil Co. of Calif., Richmond; *for mail*, 1159 Spruce St., Berkeley.

RIVERSIDE, Los Angeles Section

COLVILLE, Wm. T., Jr. (J'28), Asst. Mgr., Hendrick Ranches, 3742—10th St.
HILL, Geo. M. ('33), Asst. Mgr., Nailing Mchy. Div., Food Mchy. Corp., P. O. Box 868, 12th & Santa Fe Ry.; *for mail*, 4367 Central Ave.

ROSS, San Francisco Section

EDMUNDS, Louis L. ('14; '35), Ch. Engr., Calif. & Hawaiian Sugar Refining Corp., Ltd.; *for mail*, Ross, Marin Co.

SACRAMENTO, San Francisco Section

CAMP, Wilmer E. ('22), Owner & Mgr., W. E. Camp Co., 1219—28th St.
FITCH, Kenneth S. (J'34), Jr. Topographic Engr., Conservation Branch, U. S. Geol. Survey, P. O. Box 841.
GINOCHIO, Chas. E. (J'36), Pump Test. Engr., Pacific Gas & Elec. Co., 1100 K St.
GIVAN, Albert ('13), Ch. Engr., Sacramento Municipal Utility Dist., 300 Fruit Bldg.; *for mail*, 2175—35th St.
KEITH, J. Henry ('23; '30; '35), Sr. Valuation Engr., State Bd. of Equalization, 1015 L St.; *for mail*, 2747 Marty Way.
NOYES, Geo. E. ('31), Sr. Asst. Ch. Chemist, So. Pacific Co.; *for mail*, 2775—21st St.
SCARPINO, Wm. J. (J'36), 1813 Larkin Way.

SAN ANSELMO, San Francisco Section

CLISHAM, F. R. ('35; '35), 46 Park Dr.

SAN BERNARDINO, Los Angeles Section

KOCHER, E. J. ('34), M. E., Charge Maint., Refrigeration Sales & Maintenance, 1090 E St.
WINSTON, Jas. ('25; '35), Partner, Charge Prod., Valley Engrg. Co., 757 Columbia St.

SAN BRUNO, San Francisco Section

ALEXANDER, Keith O. (J'31), Box 513.

SAN CARLOS, San Francisco Section

DUNGAN, Donald K. (J'21), Box 393.
McINTYRE, Otis L. ('19), Instr., Applied Sci., Calif. Sch. of Mech. Arts, San Francisco; *for mail*, 408 Hillcrest Rd., San Carlos.

SAN DIEGO, Los Angeles Section

BACON, John L. ('99; '09), 2833 Nutmeg St.
BARNES, Hartwick M. ('27; '32), Test Engr., San Diego Consltd. Gas & Elec. Co.; *for mail*, 1016 Cypress Way.
BARTON, Harold (J'36), Layout Draftsman, Consltd. Aircraft Corp., San Diego; *for mail*, Hotel San Juan, Mission Beach.
BUERKLE, Elmer C. (J'35), Lt., U. S. N., Engr. Officer, U. S. S. Cachalot, c/o Postmaster.
BUTCHER, Jos. H. (J'35), 3394 Herman Ave.
COLE, Boyd B. (J'35), U. S. N. R., Aviation Cadet, VJ Squadron 1F, U. S. Naval Air Sta.
DAVENPORT, J. F. (J'34), 3850 Nile St.
GEYER, Henry E. ('25; '32; '35), Maint. Supt., Stand. Oil Co. of Calif., Box 1372.
GRIFFIN, Chas. L. ('93), Retired; Barcelona Apt. Hotel, 4th & Juniper Sts.
HULL, Jesse Lyle (J'36), Lieut., U. S. S. Narwhal, c/o Postmaster.
KLAUBER, Laurence M. ('19), V. P., Charge Oper. San Diego Consltd. Gas & Elec. Co., Box 1374.
STEFANAC, J. B. (J'36), Lieut., U. S. N., Staff, Destroyer Squad. 3, U. S. S. Hopkins, c/o Postmaster.
THORNTON, W. N. ('35), Lieut. Comdr. U. S. N., U. S. S. Dobbin.
WALTERS, Lewis J. ('26), M. E., Charge Maint., Kelco Co., Box 782.
WENDER, Max (J'36) 4911 Orchard Ave.
WORCESTER, Warren B. (J'34), Aero Draftsman, Ryan Aero. Co., Lindbergh Field; *for mail*, 4919 Cresita Dr., San Diego.

SAN FERNANDO, Los Angeles Section

HAVER, Ralph L. (J'36), 14304 Sayre Ave.

SAN FRANCISCO, San Francisco Section

ANAYA, Marvin (J'35), M. E., E. E., Design & Draftsman, Bur. of Engrg., Dept. of Pub. Wks., Rm. 367; *for mail*, 834 Faxon Ave.
AUSTIN, Paul Page, Jr. (J'17), M. E., Stand. Oil Co. of Calif., 225 Bush St.; *for mail*, 1124 Chestnut St.
BAIRD, Dudley ('21), V. P., Pac. Fdy. Co., Ltd., 3100—19th St.
BAYER, Lloyd F. ('15; '22; '35), Associated Oil Co., 79 Montgomery St.
BEGGS, Philip B. (J'36), Partner, Paul W. Beggs & Son, 665 Folsom St.; *for mail*, 1322—32nd St.
BERG, Henning J. ('17; '21; '35), M. E., Stand. Oil Co. of Calif., 225 Bush St.; *for mail*, 1840 Van Ness Ave.
BERRY, Jas. F., Jr. ('21), Cons. Engr., 373 Frederick St.
BILLETER, Robt. (J'32), Ch. Draftsman, West. Can Co., 17th & Rhode Island Sts.; *for mail*, 239 Ortega St.
BIRD, Myron ('26; '35), Pres., Mgr., Calif. Saw Wks., 721 Brannan St.
BIRDSALL, Fred'k ('22), Cons. Engr., Rm. 513, Rialto Bldg.
BIRKLAND, Stellan ('27; '29; '35), Engr., Charge Design Am. Can Co., 499 Alabama St.
BLANCKENBURG, Emil ('33), Cons. Engr., 3675 Jackson St.
BLISS, Duane L., Jr. ('24), Pres., Gen. Mgr., Dunham, Carrigan & Hayden Co., 2 Kansas St.
BLUMBERG, Frank E. ('26; '35) Draftsman, Cyclops Iron Wks., 837 Folsom St.; *for mail*, 1450 Greenwich St.
BORDEN, Wm. H. ('05; '19; '35), Mfrs. Sales Agt., Indus. Safety Devices, 765 Bryant St.
BOUICK, Jas. B. ('27), M. E., 1779—17th Ave.
BOVARD, Paul F. ('24), Pres., Calif. Filter Co., 981 Folsom St., San Francisco; *for mail*, 964 Spruce St., Berkeley.
BREED, Everett M. ('20), Pres., Gen. Mgr., Pelton Water Wheel Co., 2929—19th St., San Francisco; *for mail*, 507 Cornell Ave., San Mateo.
BREGLER, Wilfred A. C. (J'36), 670—6th Ave.
BRUBAKER, Walter S. ('20), V. P., Mgr., Granberg Meter Corp., 79 New Montgomery St., San Francisco; *for mail*, 1425 Harrison St., Oakland.
BRUCE, Albert W. (J'36), Draftsman, Stand. Oil Co. of Calif., 225 Bush St.
BUONACCORSI, Alphonse L. (J'35), M. E., Oliver United Filters, Inc., 2900 Glascock St., Oakland; *for mail*, 412 Lombard St., San Francisco.
BURNHAM, C. H. M. ('27), Ch. Engr., Coast Exploration Co., 733 Federal Reserve Bank Bldg.
CALMUS, F. A. ('27; '35), Dist. Sales Mgr., Elliott Co., 813 Rialto Bldg.
CAMERON, E. H. ('35), Sales Engr., Fairbanks, Morse & Co., 35 Spear St.; *for mail*, 950 Bay St.
CHEAL, W. C. (J'35), 3260 Gough St.
CLARK, Addison L. ('15), Pres., Am. Brake Shoe & Fdy. Co. of Calif., P. O. Box 188, S. San Francisco.
CLARK, Geo. S. (J'23), *Student Award*, '24; Stand. Oil Co. of Calif., 225 Bush St., San Francisco; *for mail*, 2207 Sunset Ave., Bakersfield.
COCKINS, W. W., Jr. (J'35), Sales Engr., Cyclops Iron Wks., 837 Folsom St., San Francisco; *for mail*, 1972 El Dorado Ave., Berkeley.
COLLINS, Glenville A. ('25), Pres, Collins Pac. Co., 490 Bay St.
COLVIN, Timothy E. (J'30), Asst. Mgr., Wheel Div., Gen. Metals Corp., 485 California St., San Francisco; *for mail*, 151 Sandringham Rd., Piedmont.
COOPER, Frederick F. ('14), Pres., Golden State & Miners Iron Wks., 249—1st St.; *for mail*, 316 Laurel St.
COZZO, S. E. ('36), M. E., West. Pipe & Steel Co., 444 Market St.
CROZIER, H. W. ('14), Cons. Engr., 58 Sutter St.
CUMMINGS, Frank S. ('19; '24; '32), M. E., C. C. Moore & Co., 450 Mission St., San Francisco; *for mail*, 1623 Visalia Ave., Berkeley.
DAM, Cyrus King (J'29), Engr. & Draftsman, San Francisco Water Dept., 425 Mason St.; *for mail*, 1411—5th Ave.
DANFORTH, Richard S. ('28), Dist. Sales Mgr., Alco Products, Inc., Rialto Bldg.
DEGENER, G. O. ('20; '35), 1190 Eddy St.
DELANY, Chas. H. ('07), Asst. Engr. Opera., Pac. Gas & Elec. Co., 245 Market St.
DENTON, Louis I. ('18), M. E., Pac. Fruit Express Co., 64 Pine St., San Francisco; *for mail*, 4119 Mountain Blvd., Oakland.
DENTRAYGUES, Jean (J'31), Plant Engr., Design. Prod., Kimball-Krogh Pump Co., 515 Harrison St.
DESTIN, P. T. (J'36), M. E., Furnace Design. Owens-Ill. Pac. Coast Co., 15th & Folsom St.; *for mail*, 1369a Greenwich St.
DICKIE, Alex J. ('20; '25; F'36), Manager, '31-'34: Editor, Pacific Marine Review, 500 Sansome St.
DIEHL, A. N. ('19), Pres., Columbia Steel Co., Russ Bldg.
DOBLE, Wm. A. ('91), Cons. Engr., Pat. Atty., Doble & Doble, 1821 Mills Tower, 220 Bush St.
DOWS, Samuel R. ('24; '26; '35), Ch. Engr., Paramount Mfg. Co., 484 Mills Bldg., San Francisco; *for mail*, 622 Curtis St., Albany.
DUNLAP, Rodney T. (J'32), Sales Engr., SKF Industries, Inc., 221—11th St.
EASTLING, Harvey V. ('22; '30), Ch. Engr., Pac. Div., Link-Belt Co., 400 Paul Ave., San Francisco; *for mail*, 1718 Easton Dr., Burlingame.
ENGLISH, Earl F. ('23), 467 Buena Vista Ave.
ESTCOURT, V. F. ('27; '32), Effic. Engr., Pac. Gas & Elec. Co., Sta. A, 430—23rd St.
EVERETT, William S. (J'36), Jr. Engr., Stand. Oil Co. of Calif., 225 Bush St., San Francisco; *for mail*, 2520 Hillegass Ave., Berkeley.
FARBAR, Leonard (J'36), Teaching Asst. (M. E.) & Graduate Study, Dept. M. E., Univ. of Calif., Berkeley; *for mail*, 10 Como St., Daly City.
FERRIER, Francis Mancel (J'36), Draftsman, West. Can Co., 17th & Rhode Island Sts.; *for mail*, 1470 Washington St.
FITZMAURICE, G. W. (J'35), Sales Engr., Pac. Fdy. Co., Ltd., 3100—19th St.; *for mail*, 2515 Octavia St.

GAYMAN, Bert A. ('14), Pres., Link-Belt Co., 400 Paul Ave.
GELTER, Stephen V. ('28; '35), Apt. 8, 1560 McAllister St.
GODSIL, Edw. C. ('32; '35), Test Engr., Pac. Elec. Mfg. Corp., 5815—3rd St.
GOLDMAN, Oscar G. ('19; '35), Asst. Supt., City Distribution Div., San Francisco Water Dept., 425 Mason St.
GRAY, Wharton K. ('28; '31; '35), Engr., Spreckels Sugar Co., Foot of 23rd St.; *for mail*, 475 Dewey Blvd.
GREEN, Andrew S. (J'36), Jr. Engr., Constr. Dept., Bethlehem Shipbldg. Corp., 20th & Illinois Sts., San Francisco; *for mail*, 2536 Grant St., Berkeley.
GRUTZMACHER, Robt. L. (J'29), Mgr., No. Div., Natural Gas Equip., Inc., 1123 Harrison St.
GUTLEBEN, Donald C. (J'35), Exper. Engr., Spreckels Sugar Co., San Francisco, Calif.; *for mail*, 47th & Pine Sts., Philadelphia, Pa.
HALL, Richard C. (J'35), Engr., Draftsman, Stand. Oil Co. of Calif., 200 Bush St.; *for mail*, 2300 Francisco.
HANSCOM, William W. ('13), Cons. Engr., 848 Clayton St.
HANSON, Fred P. ('17), Mgr. of Purchases & Stores, Pac. Gas & Elec. Co., 245 Market St.; *for mail*, 139 San Leandro Way.
HASEGAWA, Tatsuo (J'35), 3611 Sacramento St.
HATHAWAY, King ('08; '19), Cons. Engr., 1006 Merchants Exch. Bldg.
HEARTY, F. J. ('20; '35), Propr., F. J. Hearty & Co., 407 Call Bldg.; *for mail*, 2824 Filbert St.
HELBUSH, Wm. W. ('28; '35), M. E., Charge Design, San Francisco Pub. Utilities Comm., 425 Mason St.
HILLS, Leslie W. (J'21), V. P., Hills Bros., 2 Harrison St.
HIRSCH, Bertram H. (J'35), Constr. Engr., Bethlehem Shipbldg. Corp., 20th & Illinois Sts.; *for mail*, 2 Parker Ave.
HOFFMAN, John H. ('25; '30), Supt., Mar. Dept., Pac. Dist., Foster Wheeler Corp., 805 Balboa Bldg., San Francisco; *for mail*, Box 314, Kentfield, Marin Co.
HOWARD, Alfred H. ('24), 140 Vasquez Ave., Forest Hill.
HOWELL, Robt. P., Jr. (J'34), M. E., Gen. Engrg. Dept., Stand. Oil Co. of Calif., Rm. 1218, Stand. Oil Bldg.
HOXIE, V. W. ('15), Ch. Mar. Dept., C. C. Moore & Co. (Pac. Coast Reps., Babcock & Wilcox Co.), 450 Mission St.
JACOBS, Saml. S. ('23), Engr., Charge Design, Am. Can Co., 499 Alabama St.
JONES, Leon B. ('14; '26), Pres., Leon B. Jones Co., 155 Montgomery St.
JONES, Walter B. ('25; '30; '35), 119—9th Ave.
KARNASCH, L. M. ('23), Designing Engr., Pelton Water Wheel Co., 2929—19th St.
KINNEY, T. S. (J'34), Engr. & Salesman, Pac. Scien. Co., 25 Stillman St., San Francisco; *for mail*, 2508 Ridge Rd., Berkeley.
KINTER, Dean W. (J'28), Wire & Steel Inspr., Golden Gate Bridge & Highway Dist., Ft. Point; *for mail*, 1055 Washington St., San Francisco.
KLINE, M. E. ('31), Sales Engr., Union Lumber Co., 1010 Crocker Bldg.
KREMSER, Alois ('26), M. E., Stand. Oil Co. of Calif., 225 Bush St., San Francisco; *for mail*, 733 The Alameda, Berkeley.
KRIDER, Roderic M. (J'36), 1495 Golden Gate Ave.
KRUGER, Louis Robt. ('22; '35), M. E., Designer, City & County of San Francisco, City Hall; *for mail*, 1068 Minich St.
KULLMER, Frank ('32; '35), Engr., Soule Steel Co., 1750 Army St.
LANG, Alfred G. ('26), Ch. Engr., Pac. Portland Cement Co., San Francisco; *for mail*, 1107 Hamilton Ave., Palo Alto.
LETCHFIELD, Francis T. ('22), Cons. Engr., Asst. V. P., Wells Fargo Bank & Union Trust Co., 14 Montgomery St.
LINDQUIST, Edw. W. ('02; '05), Dist. Mgr., Allis-Chalmers Mfg. Co., 116 New Montgomery St., San Francisco; *for mail*, 1569 Beverly Pl., Berkeley.
LOGAN, Orwell ('17; '35), Asst. Engr., Valuation, So. Pac. Co., 65 Market St., San Francisco; *for mail*, 842 The Alameda, Berkeley.
LOSH, Clarence A. ('25; '35), Power Plant Inspr., So. Pac. Co., 65 Market St.
LYMAN, Oliver B. ('28), Mfrs. Rep., 74 Montgomery St.; *for mail*, 2675 Green St.
MACAULAY, Donald S. ('30; '35), Dist. Rep., Cent. Calif., Oakite Products, Inc., 115 Townsend St.
MACLAREN, Jas. G. ('28), Propr., Maclaren Co., 2258—26th Ave.
MACSWEENEY, Henry M. ('27; '35), Suite 715, 57 Post St.
MAKER, Frank L. ('30), Secy., Cons. Board of Engrs., Engrg. Dept., Stand. Oil Co. of Calif., 225 Bush St., San Francisco; *for mail*, 1071 Spruce St., Berkeley.
MARSHALL, A. G. ('33), Asst. Refinery Mgr., Shell Oil Co., 100 Bush St., San Francisco; *for mail*, 1600 Escobar, Martinez.
MARSHALL, Stewart M. ('07; '10), Cons. Engr., 1915 Mills Tower.
McBRYDE, Warren H. ('21), Cons. Engr., 1111 Financial Center Bldg.
McGARR, Arthur F. (J'35), Supt. Prod., Simmons Co., 295 Bay St.
McGILL, Wm. A. ('29; '35), DeLaval Pacific Co., 61 Beale St.
McSWEENEY, Jeremiah (J'35), 487—29th St.
MEEDEN, Barney L. ('28), Capt., 522 B, East Cantonment, Presidio.
MEREDITH, Wynn ('13), Res. Partner, Sanderson & Porter, 1 Montgomery St.
MILLER, Stephen C. ('24), 1318 Cole St.
MILLS, Bernard ('21), Supt., Engr., Am. Hawaiian Steamship Co., Pier 28, San Francisco; *for mail*, 155 Parkside Dr., Berkeley.
MOORE, C. Fulton, Jr. ('30), Mgr. of Plants, Natl. Ice & Cold Storage Co. of Calif., 85—2nd St., San Francisco; *for mail*, 808 S. Sierra Bonita Way, Los Angeles.
MOORES, Robt. de la Hey ('25; '32; '35), Ch. Electrician, Am. Hawaiian S. S. Co., Pier 28.
MOWATT, Wm. T. ('28), Supt., Steam & Elec. Generation of San Francisco, 220 Golden Gate Ave.
MURRAY, Warren E. ('10), Cons. Engr., 908 Hayes St.
NICCOLLS, Robt. Stanton (J'36), 57 Westgate Dr.
NOLAND, Roscoe C. ('20; '25), U. S. S. Langley, c/o Postmaster.
PADDOCK, Chas. B. ('21), Mgr., Hartford Steam Boiler Inspc. & Ins. Co., 144 Sansome St.
PARROCK, H. P. ('11), 2439 Pacific Ave.
PHILLIPS, Horace Pease ('21), Supt., Pac. Div., Link-Belt Co., 400 Paul Ave.
PLASS, Raymond B. ('25; '32; '35), Engr., W. Harry Archer & Associates, 564 Market St., San Francisco; *for mail*, 1803 Oxford St., Berkeley.
POEHLMANN, Karl F. (J'35), Lieut., U. S. N., Asst. Engr. Officer, U. S. S. Trenton, c/o Postmaster.
POTTS, W. Kenneth ('20; '21; '35), Asst. Mgr., John Phillips Co., 206 Sansome St.
QUARNSTROM, Arthur (J'30), Oper., Gas. Absorption Plant, Stand. Gasoline Co., San Francisco; *for mail*, Box 97, Avenal.
QUICK, Ray S. ('22; '35), Ch. Engr., Pelton Water Wheel Co., 2929—19th St.
RADETICH, Frank E. (J'32), Machinist, Judson-Pac. Co., 609 Mission St.; *for mail*, 779 Kansas St.
REGAN, Jos. D. (J'33), Draftsman, Bur. of Engrg., City & County of San Francisco, City Hall; *for mail*, 515—9th Ave.
REICHEL, Curt R. ('34; '35), Engr., C. R. Reichel Engrg. Co., 737 Clementina St., San Francisco; *for mail*, 929 Laurel Ave., San Mateo.
RICHARDS, Harry E. (J'36), Hull Draftsman, Bethlehem Shipbldg. Corp., 20th & Illinois Sts., San Francisco; *for mail*, Corte Madera.
RIETZ, Carl A. ('31; '34), Engr., Process Mchy. Co., 329 Tehama St.
ROEMER, Herbert (J'35), Sales Engr., Taylor Instrument Cos., 145 Mission St.
ROSENER, Leland S. ('27), Cons. Engr., 12th Fl., 233 Sansome St.
RUED, Fred H. (J'35), Jr. Engr., Pelton Water Wheel Co., 2929—19th St., San Francisco; *for mail*, 2550 Haste St., Berkeley.
RUMBLE, Virgil A. ('25; '34; '35), Mgr., San Francisco Office, Bailey Meter Co., 424 Sharon Bldg.
RUSSELL, Frank E. ('24), M. E., Charge Design & Maint., So. Pac. Co., 65 Market St.
SANDERS, John (J'27), Mech. Engrg. Designer, Bur. of Engrg., City & County of San Francisco; *for mail*, 3922—25th St.
SAUNDERS, A. B. (A'21), Ch. Engr., Oper. & Maint., Stanford Hospitals, 2361 Clay St.; *for mail*, 2550—29th Ave.
SAWIN, Herbert A. ('30; '35), Engr., Sales Dept., Yuba Mfg. Co., 351 California St., San Francisco; *for mail*, 11 Roslyn Court, Oakland.
SCHROEDER, Otto ('35), Plant Engr., Soule Steel Co., 1750 Army St.; *for mail*, 1324 Balboa St.
SHAW, Wm. C. ('20), 781—14th Ave.
SHUCKART, Josiah B. ('33), Ch. Engr., Am.-Hawaiian S. S. Co., 215 Market St.; *for mail*, P. O. Box 1128.
SIGNAROWITZ, Ferdinand J. ('15), Hyd. Engr., Pelton Water Wheel Co., 2929—19th St., San Francisco; *for mail*, 715 San Mateo Dr., San Mateo.
SMITH, Fred Bradshaw (J'36), Apprentice, Am. Can Co., 499 Alabama St., San Francisco; *for mail*, 5348 Boyd Ave., Oakland.
SMITH, Harry J. ('21), Constr. Engr., Gas Dept., Pac. Gas & Elec. Co., 245 Market St.; *for mail*, 201 Wawona St.
SMITH, Jule C. ('23), 219 Mallorca Way.
SPRINGER, Russell S. ('13), 1075 California St.
STAPLES, Earle I. ('23), Pres., Staples & Pfeiffer, Ltd., 528 Bryant St.
STEINBECK Chas. E. ('27), Asst. Engr., Charge Steam Plant Design, Pac. Gas & Elec. Co., 245 Market St.
STEVENSON, R. W. (J'34), Engr., Charge Design, Fuel Oil Conversions, Inc., 1188 Harrison St., San Francisco; *for mail*, 2844 Webster St., Berkeley.
STIGEN, Randolph (J'30), Mar. Engr., Stand. Oil Co. of Calif., 200 Bush St., San Francisco; *for mail*, 1078 Underhills Rd., Oakland.
STODDARD, Elgin ('11), Pres., C. C. Moore & Co., 450 Mission St.
STOKER, L. P. ('36), Mgr., Precision Control Co., 1257 Folsom St.
STRAUSS, Jos. B. ('30), Pres., Strauss & Paine, Inc., 111 Sutter St.
STROTT, J. Fred. (J'22), Ch. Draftsman, Link-Belt Co., 400 Paul Ave.
STURGESS, J. B. (J'34), Sales Engr., Worthington Co., Inc., 224 Townsend St.
SULLIVAN, Geo. G. (J'35), Engr., Bedaux Dept., Golden State Co., Ltd., 425 Battery St., San Francisco; *for mail*, 725 Madison St., Santa Clara.
TACCHELLA, Adolph A. ('14; '19), Engr., Busch-Sulzer Bros.-Diesel Eng. Co., 904 Rialto Bldg.
TAYLOR, Morris P. (J'27), Designing & Inspecting, So. Pac. Ry., 65 Market St., San Francisco; *for mail*, Box 524, Stanford University.
TERWILLIGER, Harry L. (A'01), Dist. Mgr., Ingersoll-Rand Co., 350 Brannan St.
TRUETT, Bertram S. (J'36), 1701 Vallejo St.
TRUMMER, David J. ('29; '35), Sales Engr., & Estimator, Otis Elev. Co., 1 Beach St.; *for mail*, 3236 Octavia St.
TSVETKOFF, Alexis P. ('28; '33; '35), Mech. Engrg. Draftsman, Merrill Co., 343 Sansome St.; *for mail*, 4646 Geary St.
VOY, E. L. ('16; '35), 221 Upper Terrace.
WADDELL, Geo. F. (A'98), Retired; 1975—18th Ave.
WALKER, Roy Pierce (J'34), Link-Belt Co.; *for mail*, 340 Highland Ave.
WEBSTER, Hugh Powell (J'36), Lieut., U. S. N., Engr. Officer, U. S. S. Perkins, c/o Postmaster.
WESTINGTON, Sydney P., Jr. (J'34), Statistician, Calif. Casualty Indemnity Exch., 1616 Mills Tower, San Francisco; *for mail*, 509 Santa Clara Ave., Alameda.
WETHERED, Woodworth ('33), Sir Francis Drake Hotel.
WHITE, Albert O. (J'31), Jr. Engr. & Draftsman, Union Ice Co., 354 Pine St.
WILKINS, Roy ('31), Ch. Engr., K-P-F Elec. Co., 855 Howard St.
WRIGHT, W. Q. ('08), Cons. Engr., Wright Corp., 486 California St.

SAN GABRIEL, Los Angeles Section

DEWEES, Norman B. (J'36), 1410 Fairview Ave.

SAN JOSE, San Francisco Section

HARDY, John S. ('29), Cons. M. E., 1536 Shasta Ave.
NORMANDIN, Clair A. (J'36), 1225 Hanchett Ave.

SAN LEANDRO, San Francisco Section

BUCHEN, Jos. C. ('18; '21), Gen. Supt., Leslie Salt Co., Alvarado; *for mail*, 340 Breed Ave., San Leandro.
HOPKINS, Geo. W., Jr. (J'24), Pat. Atty., Caterpillar Tractor Co.; *for mail*, 949 Begier Ave.

SAN LUIS OBISPO, Los Angeles Section

NEWTON, C. Vernon (J'35), Fuel Economist, Union Oil Co. of Calif., 617 W. 7th St., Los Angeles; *for mail*, Box 661, San Luis Obispo.

SAN MARINO, Los Angeles Section

BARKSTROM, Edw. C. ('23; '35), Ch. Engr., Design & Sales, Stephens-Adamson Mfg. Co., 2227 E. 37th St., Los Angeles; *for mail*, 2105 Sherwood Rd., San Marino.

SAN MATEO, San Francisco Section

CLAUSEN, Arthur W. ('22), 157 Barriolhet Ave.
EMERSON, F. Everett (J'35), Mapper & Field Engr., Gas & Elec. Depts., Pac. Gas & Elec. Co., 926 S. Claremont St.; *for mail*, 819 S. Humboldt St.

SAN PEDRO, Los Angeles Section

BAILEY, Ralph R. (J'36), c/o Chas. Biggs, 2925 Pacific Ave.
MACMILLAN, Duncan C. (J'36), Lieut., U. S. N., U. S. S. California.
MINOR, B. Stanley ('30), Ch. Engr., Regan Forge & Engrg. Co.; *for mail*, 1250 W. O'Farrell St.

SANTA CLARA, San Francisco Section

SULLIVAN, Geo. L. ('20), Dean, College of Engrg., Univ. of Santa Clara; *for mail*, P. O. Box 447.

SANTA CRUZ, San Francisco Section

FLEMING, Laurence T. ('20; '35), Cons. Engr., Rm. 1947, 120 S. La Salle St., Chicago, Ill.; *for mail*, 105 LaFonda Ave., Route 1, Box 133, Santa Cruz, Calif.
STEFFANI, Edw. C. (J'31), 181 Ocean View Ave.

SANTA MONICA, Los Angeles Section

COGHLAN, S. F. ('23; '35), 414—9th St.
DAVIS, Cecil L. (J'32), Stress Analysis, Douglass Aircraft Co., Inc.; *for mail*, 82B—6th St.
GILLETTE, Edmond S. ('19; '35), Mayor, City of Santa Monica, City Hall.
LEONARD, N. Nelson, Jr. (J'36), Clerk, Tool & Template Dept., Douglas Aircraft Co., Inc.; *for mail*, 1001—20th St.
LIPP, Jas. E. (J'33), 407 Sycamore Rd.
LUNDGREN, Agne T. (J'29), 2616—3d St.
OSSMAN, E. H. (J'34), Asst. Prod. Engr., Douglas Aircraft Co., Inc., 3000 Ocean Park Blvd.; *for mail*, 1040—10th St.
OSWALD, W. Bailey (J'32), Aerodynamic Engr., Douglas Aircraft Co., Inc., Santa Monica; *for mail*, 8920 Beverly Blvd., W. Hollywood.
REED, Lieut. Albert C. (J'29), Douglas Aircraft Co., Inc.; *for mail*, 453 Hillside Lane.
RODMAN, Wilmot Lee (J'36), 2505 Dewey St.
SCHILDHAUER, Edw. ('11), 832—21st St.
STEVENSON, Clinton H. (J'31), Stress Analysis, Douglas Aircraft Co., Inc., 3000 Ocean Pk. Blvd., Santa Monica; *for mail*, 226 S. Tower Dr., Beverly Hills.
WEST, Lorimer C. (J'34), 1207—4th St.
WHITAKER, John A. ('19; '24; '35), Designing Engr., Structures, Douglas Aircraft Co., Inc., Clover Field; *for mail*, 1243 Ocean Ave.

SELBY, San Francisco Section

KEENAN, J. Stanley (J'36), Jr. Engr., Am. Smelting & Refining Co., Selby; *for mail*, Crockett Club, Crockett.

SIERRA MADRE, Los Angeles Section

ROSEN, Moe (J'36), Lab., Calif. Div. of Highways, 3435 Serra Way, Sacramento; *home address*, 255 N. Lima St., Sierra Madre.
WRIGHT, Robt. E. ('33), Gen. Contractor, 497 W. Grandview Ave.

SOUTH GATE, Los Angeles Section

THOMSON, H. W. (J'36), Oper. Engr., Firestone Tire & Rubber Co., 2525 Firestone Blvd., Los Angeles; *for mail*, 2568 Illinois Ave., S. Gate.

STANFORD UNIVERSITY, San Francisco Section

CRANDALL, John Roderic (J'36), Box 618.
DOMONOSKE, Arthur B. ('12; '14; '35), Prof., Exec. Head M. E. Dept., Stanford Univ., Box 2696.
DURAND, Wm. F. ('83; H'34), Vice-President, '11-'13; President, '25; Prof. Emeritus, M. E., Rm. 542, Aero Lab., Stanford Univ.
FINCH, Volney C. (28), Prof. M. E., Stanford Univ.; *for mail*, Rm. 281A.
GREEN, Boynton M. ('21; '35), *Student Award*, '16; Assoc. Prof. M. E., Stanford Univ.; *for mail*, 691 Salvatierra St.
GULLIKSON, Albert C. ('25; '35), Asst. Prof. M. E., Stanford Univ.
HOLDEN, Paul E. ('26), Prof. Indus. Mgmt., Graduate Sch. of Business, Stanford Univ.
HUGO, Merrill S. ('25; '36), Asst. Prof. M. E., Stanford Univ., Stanford University; *for mail*, 695 Mariposa Ave., Mountain View.
NILES, Alfred S. ('27), Prof. Aero. Engrg., Stanford Univ.
TIMOSHENKO, Stephen ('24), *Worcester Reed Warner Medallist*, '35; Prof. Theoretical & Applied Mechanics, Stanford Univ.
WASHINGTON, Lawrence (J'22), Instr. M. E. Stanford Univ., 504 The Quad.

SUNNYVALE, San Francisco Section

POLOMIK, Edw. E. (J'35), 450 Matilda Ave.

SUTTER, San Francisco Section

CLARAGE, Harry L. (J'35).

TAFT, Los Angeles Section

DAWSON, Carlton W. (J'31), Engr., Stand. Oil Co. of Calif., Bin XX.

TEMPLE CITY, Los Angeles Section

KLAAS, G. P. ('30), M. E., Designer, C. F. Braun & Co., 1000 Fremont St., Alhambra; *for mail*, 429 N. Sultana St., Temple City.
KRAMER, Robt. L. (J'35), 255 S. Encenita Ave.

TORRANCE, Los Angeles Section

FAULKNER, David S. ('12; '13; '35), V. P., Natl. Supply Co. of Calif.
FREEMAN, Robt. B. (J'32), Metallographer, Columbia Steel Co.; *for mail*, 1748 Martina Ave.
GEDDES, Truman G. (J'36), Draftsman, Natl. Supply Co. of Calif., Border Ave.
LONG, Spencer W. (J'29), Mch. Designer, Natl. Supply Co. of Calif., Torrance; *for mail*, 100 N. Guadalupe Ave., Rodondo Beach.
SEMENETZ, Karl R. ('29), Plant Engr., Charge Constr., Repair, Maint. & Drafting Rm., Columbia Steel Corp., Drawer 998.
STONE, Bert L. ('30), Ch. Engr., Hydril Co.
TIMBS, Edw. ('19; '35), Ch. Engr., Charge Design, Natl. Supply Co. of Calif., 1524 Border St., Torrance; *for mail*, 5131—10th Ave., Los Angeles.

TRONA, Los Angeles Section

EASON, J. John ('16), Ch. Engr., Am. Potash & Chem. Corp.
HANSON, Hubert C. (J'35), M. E., Am. Potash & Chem. Corp.
HARRIS, Lowell B. (J'34), Mech. Draftsman, Am. Potash & Chem. Corp.
HOFFMAN, Albert A. ('18), Calif. Mgr., Am. Potash & Chem. Corp.
HOOD, B. B. ('30), Asst. Mgr., Am. Potash & Chem. Corp., Trona, Calif.; *for mail*, 70 Pine St., New York, N. Y.
POWELL, Wm. T. ('31; '35), Engr., Sr. Draftsman, Am. Potash & Chem. Corp.; *for mail*, 17 California St.

VAN NUYS, San Francisco Section

MacLAREN, Malcolm N. ('99), Retired; 4034 Ventura Canyon Ave.

VENICE, Los Angeles Section

CAPP, Wm. C. (J'32), Lieut., U. S. A., Pilot, Army Air Corps, Luke Field, T. H.; *home address*, 2507 Pacific Ave., Venice, Calif.
MARTIN, Victor J. (J'35), 2201 Lincoln Blvd.

VENTURA, Los Angeles Section

PEARCE, Stanley (J'29), Div. Engr., Prod. Dept., Shell Oil Co., Ventura Ave., Ventura; *for mail*, 1924 W. 43rd St., Los Angeles.

VERNON, Los Angeles Section

ANDERSON, Jas. Louis (J'35), Asst. Plant Engr., Bethlehem Steel Co., Slauson Ave., Vernon; *for mail*, 6421 Arbutus St., Huntington Park.
NAYLOR, Franklin L., Jr. (J'31), Draftsman, U. S. Spring & Bumper Co., 4951 Magnolia Ave., Vernon; *for mail*, 5301—11th Ave., Los Angeles.
WILBURN, Jack ('35; '35), Sales Engr., Baash Ross Tool Co., 5512 S. Boyle Ave., Vernon; *for mail*, 3117 Zoe Ave., Huntington Park.

VISALIA, San Francisco Section

PAULL, W. R. ('31; '35), Branch Mgr., Visalia Factory, P. O. Box 368.

WATSON, Los Angeles Section

EHRHART, Geo. W. (J'33), Jr. M. E., Refinery Utilities, Shell Oil Co., Watson; *for mail*, 502 S. Bradfield Ave., Compton.

WILMINGTON, Los Angeles Section

DREYER, Elmer L. (J'27), Supt., Pipe Line Dept., Tex. Co., P. O. Box 817.
HIGGINS, Q. D. ('30; '35), 1310½ Marine Ave.
MAYSE, Geo. F. (J'33), Jr. Engr., Design & Estimating, Shell Oil Co., Box 728.
SALBADOR, Hugh W. ('21), Lub. Engr., Tex. Co., Box 397.

CANAL ZONE

ANCON

RYDER, Kenneth F. (J'34), Asst. to Supt., Motor Transportation Div., Supply Dept., Panama Canal; *for mail*, Box 1992.

BALBOA

SHUMAN, Lloyd E. (J'35), Draftsman, Signal Office, Quarry Heights; *for mail*, Box 699, Balboa.

BALBOA HEIGHTS

HEDGES, Selby E. ('18; '24), Ch. Draftsman, Panama Canal, P. O. Box 71.
WHITE, W. J. ('36), Box 44.

GATUN

Van SICKLEN, Wm. A., Jr. (J'35).

MOUNT HOPE

BROWN, Richard R. (J'35), Recorder, Commissary Div., Panama Canal.

PEDRO MIGUEL

FOOTE, Leonard ('22; '28), Asst. Supt., Dredging Div., Panama Canal; *for mail*, Drawer "C."
STOCKHAM, Roy (J'32), Oper., Locks Div., Panama; *for mail*, Box 335.

COLORADO

BOULDER, Colorado Section

BAUER, Frank S. ('20; '35), Prof. M. E., Univ. of Colo.; *for mail*, 944 Lincoln Pl.
DeLUCA, Ernest (J'36), Asst. Field Engr., Engrg Dept., Pub. Serv. Co. of Colo., Valmont; *for mail*, 24th St. & University Ave., Boulder.
DOBBINS, George S., Jr. (J'30), Instr., M. E. Dept., Univ. of Colo.
HASTINGS, Abbott Q. (J'35), 1400 Broadway.
HUNTER, John A. ('14; F'36), Manager, '32-'35; Vice-President, '35-'37; Prof. M. E., Univ. of Colo., Engrg. Bldg.
MALLORY, Walter F. ('18; '30), Prof. M. E., Univ. of Colo.; *for mail*, 915—15th St.
SIMMERING, S. L. ('18; '30), Acting Head, M. E. Dept., Univ. of Colo.; *for mail*, 860—14th St.

BRECKENRIDGE, Colorado Section

PEABODY, Elmer Clifton (J'33).

COLORADO SPRINGS, Colorado Section

BURG, John (J'32), Fireman, Light & Power Dept., City of Colorado Springs; *for mail*, Adams Crossing.

DENVER, Colorado Section

ABDUN-Nur, Edw. A. (J'24), Soils Technician, Charge Ralston Lab., Bd. Water Commissioners; *for mail*, 4030 Quitman St.
ALLEN, Clifton H. (J'16), Apt. 5, 290 S. Humboldt St.
ALLEN, Frank C. (J'31), Asst. Engr., Dept. Engrg. Analysis, U. S. Bur. of Reclamation; *for mail*, 4455½ King St.
BEATTY, Chas. Edw. (J'31), Power Sales Engr., Pub. Serv. Co. of Colo.; *for mail*, 855 S. Columbine St.
BENTON, Homer W. ('31), Engr., U. S. Bur. of Reclamation, 19th & Stout Sts.; *for mail*, 1740 Sherman St.
BIER, Peter ('27; '35), Engr., Charge Penstock Design, U. S. Bur. of Reclamation, 440 Custom House.
BISHOP, J. O. (J'34), Mech. & Asst. Ch. Engr., Denver Ice & Cold Storage Co., Denver; *for mail*, Bear Lake Lodge, Estes Park.
BRENNAN, M. G. ('29; '35), Engr., Charge Power, Gas & Oil Dept., Stearns-Roger Mfg. Co., 1718-20 California St.; *for mail*, 1312 Milwaukee St.
BROOKS, G. Irving (J'33), Jr. Engr., U. S. Bur. of Reclamation, Custom House.
BURKE, E. R. (J'35), 1025 Ogden Ave.
BURRITT, Jos. R. (J'33), Jr. M. E., Concrete Research, U. S. Bur. of Reclamation, Custom House.
BYERS, Harry R. ('19; '25), 444—17th St.; *for mail*, 531 Franklin St.
CARTER, Geo. W. (J'33), Jr. Engr., Inspc. Div., Pub. Wks. Admin.; *for mail*, P. O. Box 971.
CHAPUT, Arthur J. ('30; '35), Traveling Inspr., U. S. Bur. of Reclamation.
CLARK, Hiram W. ('21; '26), Dist. Rep., Charge Sales, Iron Fireman Mfg. Co., 3170 W. 106th St., Cleveland, Ohio; *for mail*, 634 Birch St., Denver, Colo.
DAVIS, Arthur Clayton (J'36), 1352 Downing St.
DAY, Charles Mortimer ('29), M. E., U. S. Bur. of Reclamation, Custom House.
EK, Gustaf C. ('22; '35), Designer, Great West. Sugar Co.; *for mail*, 1550 Magnolia St.
FORDHAM, Nicholas E. (A'30), M. M., Inspc. & Installation Mchy., U. S. Bur. of Reclamation, Custom House, Denver, Colo.; *for mail*, Ridgley Apt. Hotel, Birmingham, Ala.
FOX, Rudolph H. ('13; '19; '35), V. P., Vulcan Iron Wks. Co., 1423 Stout St.
FRANKUM, J. B. ('21; '29; '35), Asst. Power Plant Design, U. S. Bur. of Reclamation, 440 Custom House.
GRIMSHAW, Wm. F. (J'21), Sales Engr., Ingersoll-Rand Co., 1637 Blake.
HANSEN, Alf (J'28), Dist. Turbine Engr., Gen. Elec. Co., 650—17th St.
HARDAWAY, Warren D. ('29), Supt., Hydroelectric Prod. & Transmission, Pub. Serv. Co. of Colo., 900—15th St.
HARTBURG, Herman Louis ('23; '28), Dist. Engr., Great West. Sugar Co., 600 Sugar Bldg.
HEIDINGER, Fritz (J'26), Asst. Engr., U. S. Bur. of Reclamation; *for mail*, 1771 Pennsylvania St.
HILL, Arthur L. (J'24), Engr. & Chemist, Natl. Fuse & Powder Co., 3801 Delgany St.; *for mail*, 807 Lafayette St.
HINMAN, L. R. ('30), 1170 Sherman St.
HOFFMAN, Harry L. (J'35), Cost Accountant, Denver Equip. Co., 1419—17th St.
KOONTZ, D. L. ('24), D. L. Koontz & Co., 1720 Sherman St.
LARSON, Delmar T. (J'33), Engrg. Draftsman, Gardner-Denver Co., 39th at Williams St.; *for mail*, 1710 E. 33d Ave.
MASON, John E. ('30), 1718 California St.
MATTHEWS, Benj. H. (J'36), Matls. Testing, Gen. Iron Wks.; *for mail*, 2540 Fairfax St.

McCULLOCH, John A. ('12), 1546 Williams St.
McLENNAN, J. A. ('33; '35), Assoc. Engr., U. S. Bur. of Reclamation, Custom House.
McQUAID, Dan J. ('26), Sales Engr., Lecturer, Taylor Instrument Cos. of Rochester, N. Y., Mgr., Mountain States Territory; *for mail,* 614 Cooper Bldg., Denver, Colo.
MITCHELL, Wm. A. ('18), M. & E. E., Mine & Smelter Supply Co., 1422—17th St.; *for mail,* 1255 Pennsylvania St.
MOSES, Eliot B. ('23; '30), Assoc. Engr., Elec. Sec., Mech. Div., U. S. Bur. of Reclamation, Custom House.
MURRAY, John A. (J'32), Dist. Eng., Iron Fireman Mfg. Corp., Cleveland, Ohio; *for mail,* 2511 Dexter St., Denver, Colo.
NELSON, Manley R. (J'25), Asst. Prod. Engr., Gen. Iron Wks. Co.; *for mail,* 3355 E. 5th Ave.
O'ROURKE, Patrick E. T. ('31; '35), Supvr. Engr., Ocean Accident & Guarantee Corp., Ltd., 908 Gas & Electric Bldg.
PARCE, J. Y., Jr. (J'25), Engr., Colo. Iron Wks., 1624—17th St.; *for mail,* 2057 Fairfax St.
PARMAKIAN, John (J'31), M. E., Charge M. E. Tests, U. S. Bur. of Reclamation, U. S. Custom House.
PROUTY, Frank H. ('25), Partner, Prouty Bros. Engrg. Co., Exchange Bldg.
REDDICK, Marshall E. ('26; '32; '35), Mgr. Denver Office, Bailey Meter Co., 702 Midland Savings Bldg.
RICHTER, Geo. A. ('24; '35), Sales Engr., Denver Fire Clay Co., P. O. Box 1107.
RIENKS, Geo. W. ('18), Supvg. Engr., Great West. Sugar Co., Sugar Bldg.
SCHOEPHOESTER, K. F. (J'31), Hartford Steam Boiler Inspc. & Ins. Co., 917 Gas & Elec. Bldg.
SHEDA, Harold E. (J'31), Asst. Engr., M. E. Dept., U. S. Bur. of Reclamation, Custom House; *for mail,* 421 S. Emerson St.
SHEDA, Raymond M. (J'34), Lab. Asst., Henry E. Wood Assaying Co., 1750 Arapahoe St.; *for mail,* 421 S. Emerson St.
SHEPARD, Frank E. ('89; '02), M. E., 1300 Columbine St.
STEARNS, Thos. B. ('83; F'36), Vice-President, '11-'13; Pres., Stearns-Roger Mfg. Co., 1716 California St.
THRONE, Robt. F. ('28), Supt. Steam Prod., Pub. Serv. Co. of Colo., 900—15th St.
TOFANI, B. Joseph (J'36), U. S. Bur. of Reclamation, 440 Custom House.
VAN LAW, Durbin ('19; '26), Cons. Engr., Suite 710, 1730 Glenarm St.
WEBER, Eugene ('23), 1608 Cook St.
WEED, Don C. (J'33), Jr. Engr., Hyd. Research, U. S. Bur. of Reclamation, Custom House.
WERNER, Wm. A. (J'35), Jr. Engr., Field Wk., U. S. Bur. of Reclamation, Custom House, Denver; *for mail,* 866—4th Ave, Durango.
WHITE, Britton ('25; '35; '35), Indus. Engr., 803 Security Bldg.
WOELBING, Geo. H. ('34), Engr., Charge Design, Ruth Co., 310 Continental Oil Bldg.
WOOD, Iver C. ('23; '34), Engr., Charge Maint. & Design, Denver Fire Clay Co., 1742 Champa St.

ENGLEWOOD, Colorado Section

LUCKING, Walter T. (J'35), 3126 S. Cherokee.

FORT COLLINS, Colorado Section

BUIRGY, Rob Roy (J'33), Jr. Engr., Hyd. Research, U. S. Bur. of Reclamation; *for mail,* 214 West St.
CRAIG, Dudley P. ('25), Prof., Head Mech. Engrg. Dept., Colo. State College.
CRAIN, L. D. ('14), Bldg. Supt., Colo. State College; *for mail,* 810 S. College Ave.
CULLER, Chas. D. (J'35), 512 S. Loomis.

GOLDEN, Colorado Section

ALLEN, Maynard C. ('34), Ch. Draftsman, A. J. Weinig, Cons. Engr.; *for mail,* Route 3, Box 259.
MORTON, Roscoe W. ('24; '30; '32), Prof. M. E., Colo. Sch. of Mines, Stratton Hall; *for mail,* P. O. Box 314.

GRAND JUNCTION, Colorado Section

HOTTES, H. H. (J'30), Surveyman, Denison Dam Project, Corps of Engrs., U. S. A., Denison, Tex.; *for mail,* 707 N. 7th St., Grand Junction, Colo.

GUNNISON, Colorado Section

MORLAN, Erwin A. (J'34), Rodman, U. S. Bur. of Reclamation.

LITTLETON, Colorado Section

HART, Fred W. ('19), Pres. Brookridge Farm, Inc.

MANCOS, Colorado Section

BROWN, Herbert Henry ('24).

MONTE VISTA, Colorado Section

KANIK, R. M. ('29), 1030 Park Ave.

PUEBLO, Colorado Section

CROWDER, Wilbur L. (J'35), Asst. Engr., Section Dept., Colo. Fuel & Iron Co.; *for mail,* 1819 Cedar St.
DAYTON, Frank ('28), Designing Engr., Colo. Fuel & Iron Co.

SPRINGFIELD, Colorado Section

FALK, Melvin L. (J'36).

SUGAR LOAF, Colorado Section

VANT, I. Norton (J'33), Mgr., Franklin Mining Co., Sugar Loaf; *for mail,* 4900 W. 29th Ave., Denver.

WINDSOR, Colorado Section

BROOKOVER, Paul E. (J'31), Dist. Mgr., Pub. Serv. Co. of Colo.

CONNECTICUT

ANSONIA, New Haven Section

HALPIN, Jas. F. (A'18), Gen. Supt., Seymour Mfg. Co., Seymour; *for mail,* 38 William St., Ansonia.
HOOK, Ira Thomas ('20), Research Engr., Am. Brass Co., Ansonia; *for mail,* 494 Norton Pkwy., New Haven.
HOPKINS, Sidney Lewis (J'33), Cost & Prod. Engr., Am. Brass Co.; *for mail,* 7 Jackson St.
LEWIS, Richard Chas. ('21; '33), Rolling Mill Engr., Farrel-Birmingham Co., Inc., 25 Main St.; *for mail,* 29 Judson Pl.
TANN, Walter L. ('34), Engr. Charge Prod. & Methods, Farrel-Birmingham Co., Inc.
THOMAS, Raymond H. ('14; '20; '35), Engrg. Dept., Farrell-Birmingham Co., Inc., 25 Main St.; *for mail,* 39 Holbrook St.

BETHANY, New Haven Section

CLARK, Irving W. (J'34), Warren Webster & Co., 902 Chapel St., New Haven; *for mail,* Bethmour Rd., Bethany.

BLOOMFIELD, Hartford Section

JOHNSON, Clinton V. ('31; '35), Sales Engr., Pratt & Whitney Div., Niles-Bement-Pond Co., 436 Capitol Ave., Hartford; *for mail,* Loeffler Rd., R. F. D. 1, Bloomfield.

BRANFORD, New Haven Section

TROJANOSKI, Henry Victor (J'36), Tool Engr. Jenkins Bros., 510 Main St., Bridgeport; *for mail,* 28 Hillside Ave., Branford.

BRIDGEPORT, Bridgeport Section

BAILEY, Chas. J. ('21; '23; '35), Sales Engr., Bridgeport Brass Co.; *for mail,* 55 Laurel Ave.
BARIFFI, Herbert Frank (J'30), Engr., Home Appliance Engrg. Dept., Gen. Elec. Co., 1285 Boston Ave., Bridgeport; *for mail,* 75 Park Ave., Hamden.
BEARD, Theo. H. ('17; '25), V. P., Dictaphone Corp., 375 Howard Ave.
BECK, Rudolf ('27), Engr., Charge Instrument Devel., Consltd. Ashcroft-Hancock Co., Inc.; *for mail,* University Club.
BEEDE, Arnold H. (J'33), Engr., Research Dept., Dictaphone Sales Corp., 375 Howard Ave.; *for mail,* R. F. D. 4, Box 492.
BLANCHARD, E. Payson ('35), Sales Mgr., Bullard Co.
BRENZINGER, Julius ('15), V. P., Gen. Mgr., Charge Design, Max Ams Mch. Co.
BREWER, Arthur ('06), Asst. Wks. Mgr., Mill Products Div., Bridgeport Brass Co., 774 E. Main St.; *for mail,* 100 Unquowa Hill.
BULLARD, Dudley B. ('99), V. P., Charge Design, Bullard Co., Canfield Ave., Bridgeport; *for mail,* Main St., Southport.
BULLARD, Edw C. ('29), V. P., Gen. Mgr., Bullard Co., Canfield Ave.; *for mail,* 28 Sherley Pl.
BULLARD, Edw. P. ('13), Pres., Bullard Co., Canfield Ave.
CARD, Frederic M. ('06), 116 Edna Ave.
CLARK, Walter R. ('08; '14), Wks. Mgr., Mill Products Div., Bridgeport Brass Co., E. Main St.; *for mail,* 225 Golden Hill St.
CROCKER, Ernest B. ('17), M. E., Safety Valve Div., Consltd. Ashcroft Hancock Co., Inc., Elias St.
DEERING, Emil E. (J'34), 315 Palisade Ave.
EDWARDS, Arthur (J'23), Test. Engr., Raybestos-Manhattan, Inc., Railroad Ave., Bridgeport; *for mail,* 936 Judson Pl., Stratford.
GILLEO, Wallace F. ('23; '35), 850 Stratford Ave.
HAGAN, Albert W. ('29; '35), Ch. Engr., Wolverine Motor Wks. Inc., Union Ave.; *for mail,* 95 Waterman St.
HANSEN, W. T. (J'35), 238 Mt. Grove St.
HARRIS, H. Patterson (A'18), Asst. to Gen. Sales Mgr., Bryant Elec. Co., Bridgeport; *for mail,* "Ivy Hill," Southport.
HARRIS, Harry Ezekiel ('11), Life Member, Cons. Engr., 229 Thorme St.
HILSTROM, Hollis R. (J'35), Wage Analyst, Gen. Elec. Co., 1285 Boston Ave.; *for mail,* 72 Marion St.
HOAGLAND, Cecil N. ('29; '36), Mgr., Lindstrom Tool & Toy Co., 50 Silliman Ave.; *for mail.* 119 Sterling Pl.
IORILLO, Domenick Jos. (J'36), Inspr., Bridgeport Brass Co., E. Main St.; *for mail,* 2010 Seaview Ave.
KEATING, Daniel A. ('13), Ch. Engr., Stanley Wks., Am. Tube & Stamping Plant, Seaview Ave.
LANGE, Paul H. ('14), Engr., 50 Beacon St.
LOCKWOOD, Geo. W. ('24), Supt., Columbia Phonograph Co., Inc., Bridgeport; *for mail,* 64 Rowland Rd., Fairfield.
LUCARELLE, Jos. M. ('29), Gen. Supt., Dictaphone Corp., 375 Howard Ave.; *for mail,* 53 Wade St.
PANISH, Erwin J. ('21; '35), Cons. Engr., 70 Beacon St.
RICHMOND, Oscar J. ('35), Ch. Engr., Power Plant, United Illum. Co., 1115 Broad St.
SKINNER, Jas. D. ('15), Pres., Fuller & Co. Inc., 955 Main St.
STANSFIELD, Frank H. ('16; '35), Community Chest & Council, Inc., 881 Lafayette; *for mail,* 31 Pacific St.
SWEET, Corlise M. (J'32), 1234 Iranistan Ave.
TANNER, Fred'k C. ('26; '33; '35), Supvr., Inspc. Dept., Gen. Elec. Co., Boston Ave., Bridgeport; *for mail,* 11 Clarkson St., Ansonia.
THOMPSON, Daniel G. (J'31), Time Study Engr., Gen. Elec. Co.; *for mail,* 1151 Central Ave.
UHL, Edw. L., Jr. (J'36), Engrg. Dept., Bridgeport Brass Co., E. Main St.
VAN YORX, John H., Jr. ('17), Tech. Sales Promotion, Bullard Co., Bridgeport; *for mail,* 1st Ave., Lordship Manor, Stratford.
VISCUSI, Wm. E. (J'36), Draftsman, Shelton Tubular Rivet Co., Shelton; *for mail,* 352 Wilmot Ave., Bridgeport.
WEBSTER, Wm. Reuben ('93; '07), Chmn. of Board, Bridgeport Brass Co.; *for mail,* 208 Brooklawn Ave.
WELLS, Herbert E. ('17; '35), Supt. Tool Div., Gen. Elec. Co.; *for mail,* 249 Huntington Rd.
WESTERBERG, C. Frederick ('22), Ch. Draftsman, Stanley Wks., Am. Tube & Stamping Plant, Seaview Ave.; *for mail,* 360 Gurdon St.
WILMOT, Russell C. ('17; '35), Prod. Mgr., Gen. Elec. Co., Bond St.; *for mail,* 165 Brookview Ave.
ZINSSER, August, Jr. (J'35), Sikorsky Aircraft Corp.

BRISTOL, New Britain Section

BARNES, Fuller F. (A'19), Chmn. Bd., Wallace Barnes Co., 18 Main St.
COOK, Raymond W. ('27), V. P., Charge Wks., Wallace Barnes Co., 18 Main St.
EDWARDS, Henry Harmon ('16; '26), 101 Stearns St.
FITZ, Arthur E. ('27), M. E., Planning Dept. & Power Engr., Wallace Barnes Co., Main St.; *for mail,* Witches Rock Rd.
GEARING, Chas. M. ('21), Mgmt. Advisor, New Departure Mfg. Co., Gen. Motors Corp.
GOEDECKE, Mark (J'35), Engrg. Dept., New Departure Mfg. Co., Gen. Motors Corp., Bristol; *for mail,* 649 Broad St., Meriden.
GURSKE, Hubert J. (J'30), Lab. Test Wk., New Departure Mfg. Co., Gen. Motors Corp.; *for mail,* 23 South St.
HOLMQUIST, Geo. F. ('20; '35), Devel. Engr., 674 Farmington Ave.
HUGHES, Fred'k G. ('13), Gen. Mgr., New Departure Mfg. Co., Gen. Motors Corp., N. Main St.
KNOTT, Maurice John (J'35), Engrg. Dept., New Departure Mfg. Co., Gen. Motors Corp.; *for mail,* 115 North St.
MABB, Wm. S. (J'35), Engr., Design, New Departure Mfg. Co., Gen. Motors Corp., N. Main St.
MARINO, S. Francis (J'28), M. E., New Departure Mfg. Co., Gen. Motors Corp., Bristol; *for mail,* 60 Whiting St., Plainville.
RAMM, Henry F. (J'36), Design Engr., New Departure Mfg. Co., Gen. Motors Corp., Bristol; *for mail,* 376 Washington St., Forestville.
SPICACCI, A. R. ('28; '34), Asst. Ch. Engr., New Departure Mfg. Co., Gen. Motors Corp., Main St.
STEIN, Chas. P. (J'26), 10 Walnut St.
STEVENS, Clarence C. ('21; '28), M. E., Charge of Design & Devel., Asst. to Factory Mgr., New Departure Mfg. Co., Gen. Motors Corp.
VUILLEUMIER, Albert ('16; '35), Ball Plant Supt., New Departure Mfg. Co., Gen. Motors Corp., N. Main St.; *for mail,* P. O. Box 245.
WARFEL, Robt. A. (J'30), M. E., Prod., New Departure Mfg. Co., Gen. Motors Corp.; *for mail,* Dorothy Rd.

CLINTON, New Haven Section

STEVENS, Alfred H. ('98; '03), 1st Selectman, Town of Clinton; *for mail*, 33 High St.

COLLINSVILLE, Hartford Section

BLOUNT, Wayne L. (J'32), Power Plant Oper., Collins Co.; *for mail*, Box 563.

CROMWELL, Hartford Section

COE, Raymond S. ('20; '35), P. O. Box 153.

DANBURY, Waterbury Section

GENEST, Homer A. ('20), Ch. M. E., U. S. Hat Machy. Corp.
HATCH, Gordon H. (J'34), Inspr., Bard Parker, Inc., Lemac Ave.; *for mail*, R. F. D. 5.
SUSKA, Chas. R. (J'36), Training, Stanley Rule & Level Co., Elm St., New Britain; *for mail*, 8 Wilson St., Danbury.
WELLS, Burling D. ('19; '27; '35), Indus. Engr., Mallory Hat Co.; *for mail*, 39 Lake Ave.

DARIEN, Bridgeport Section

DAVIS, Chas. Ethan ('96), Retired; Five Mile River Rd.

DERBY, New Haven Section

LOMBARDI, Wm. A. (J'30), Sentinel Hill.
SHEA, Jos. B. (J'32), Engr., Charge Time Study & Cost Estimates, Hershey Metal Products, Inc.; *for mail*, 12 Cottage St.

EASTFORD, Norwich Section

TROWBRIDGE, Amasa ('92; '03).

EAST HARTFORD, Hartford Section

COLE, Gilmoure N. (J'31), Checking Engr., Design & Drawings, Pratt & Whitney Aircraft Co., E. Hartford; *for mail*, 11 Alden St., Hartford.
CROCKER, Albert R. (J'36), Graduate Student, N. Y. Univ., University Heights, New York, N. Y.; *home address*, 16 Gold St., E. Hartford, Conn.
DARROW, Warren E., Jr. (J'35), Draftsman, Engrg. Dept., Hamilton Stand. Propellers, E. Hartford; *for mail*, 6 School St., Glastonbury.
DAY, Alfred V. (J'35), Tester, Pratt & Whitney Aircraft Co., E. Hartford, Conn.; *for mail*, 8 Rosseter St., Dorchester, Mass.
DEBRUYN, Peter R. (J'35), Test Engr., Pratt & Whitney Aircraft Co., E. Hartford; *home address*, 19 Grove St., W. Hartford.
INGLISH, Harold C. (J'35), Tech. Inspr., Chance Vought Aircraft, Div. of United Aircraft Corp., E. Hartford; *for mail*, 56 Chestnut St., Manchester.
KEARNS, Chas. M. (J'36), 76 Ensign St.
LARSON, Norman F. (J'33), Exper. Test Engr., Pratt & Whitney Aircraft Co., E. Hartford; *for mail*, Apt. B-4, 24 Denison St., Hartford.

EAST HAVEN, New Haven Section

BARROWS, John (J'36), 28 Center Ave.

EAST NORWALK, Bridgeport Section

McCLOUGHAN, Chas. (J'34), Asst. Plant Engr., M. E., Hat Corp. of Am.

ELMWOOD, Hartford Section

BOURGARD, Frank D. (J'28), Whitlock Coil Pipe Co., Elmwood; *for mail*, 377 Sigourney St., Hartford.

FARMINGTON, Hartford Section

WARD, J. CARLTON, Jr. ('17; '25), Asst. Gen. Mgr., Pratt & Whitney Aircraft Co., E. Hartford; *for mail*, High St., Farmington.

GEORGETOWN, Bridgeport Section

LINDSTROM, Wm. J. (J'35), Time Study Dept., Gilbert & Bennett Mfg. Co.; *for mail*, P. O. Box 83.

GREENWICH, Bridgeport Section

BONNETT, J. Calvin ('21; '35).
BOORAEM, J. Francis ('95; '06), Cons. Engr., Specialist in Swimming Pool Design, Constr. & Equip., Shore Rd.
CILIA, Odo Jos. (J'36), 104 Hamilton Ave.
DOWNING, Burton H. ('24; '35), 80 W. Putnam Ave.
HAYNES, Hasbrouck ('12; '19; '28), Pres., Haynes Corp.; *for mail*, 282 Overlook Dr.
MINTON, Ogden ('26), Owner, Vacuum Paper Mch. Dryers, P. O. Box 333.
SOUTHACK, Tilden W. (J'33), Test Engr., Acrotorque Co., 19 Whitney Ave., New Haven; *for mail*, Cherry Hill Rd., Greenwich.
STREET, Clement F. ('93), Cons. Engr., 361 Shore Rd.
WINTON, L. B. ('22; '35), Cons. Engr., P. O. Box 595.

GROTON, Norwich Section

ANDRIOLA, Achilles D. (J'35), Calculator, Elec. Boat Co.; *for mail*, 50 Riverview Ave.
BOER, Westinus ('32), Engr., Charge Design Calc. Dept., Elec. Boat Co.; *for mail*, Long Hill Rd.
DENNISON, Edw. S. ('24; '32), Engr., Charge Diesel Eng. Devel., Elec. Boat Co.
SPEAR, Lawrence Y. ('15), V. P., Elec. Boat Co., Groton & Gardner Ave., New London.

GUILFORD, Norwich Section

NORTON, Geo. H. (J'34), 26 Pearl St.

HAMDEN, New Haven Section

HAUGHTON, H. O. ('34), 44 Ardmore St.
RICONDA, Leo J. (J'34), Experimental-Test Engr., Safety Car Htg. & Ltg. Co., Hamden, Conn.; *for mail*, 162 Ditmar St., City Island, New York, N. Y.
WARNER, Oswin V. (J'36), Apprentice Fdy. Engr., Malleable Iron Fittings Co., Branford; *for mail*, 1679 Dixwell Ave., Hamden.

HARTFORD, Hartford Section

ALTORFER, Hans (J'30), M. E., Charge Thermodynamics, Terry Steam Turbine Co., Hartford; *for mail*, 1419 Blvd., W. Hartford.
ANTHONY, Graham H. ('16; '25), Pres., Veeder-Root, Inc., 20 Sargeant St.
BACHMANN, Alwin B. ('22), M. E., Charge Design Keller Mchs., Pratt & Whitney Div., Niles-Bement-Pond Co., 436 Capitol Ave.
BARNARD, W. Grover (A'22), Bldg. Supt., Hartford Elec. Light Co., 266 Pearl St.
BEEKLEY, Waldron C. ('16; '35), V. P., Whitlock Coil Pipe Co., Hartford; *for mail*, 141 Raymond Rd., W. Hartford.
BILLINGS, Frederic C. ('91), Pres., Billings & Spencer Co., 1 Laurel St.
BURDICK, Herbert ('17; '23), M. E., Underwood Elliott Fisher Co., 56 Arbor St.; *for mail*, 198 N. Oxford St.
BURT, Clayton R. ('09), Pres., Niles-Bement-Pond Co., Gen. Mgr., Pratt & Whitney Div., 436 Capitol Ave.
CAMERON, John A. ('32), Foreman, Charge Auto. Screw Mch., Veeder-Root, Inc., 32 Sargeant St., Hartford; *for mail*, 22 High St., Bristol, Conn.
CASSIDY, Thos. F., Jr. (J'29), E. E., Design & Research, Gray Tel. Pay Sta. Co., 30 Arbor St.; *for mail*, 121 Tredeau St.
CHAPLIN, John H. ('20; '26; '27), Veeder-Root, Inc.
CLEVELAND, Frank W. ('18; '21), Div. Supt., Underwood Elliott Fisher Co., 581 Capitol Ave.; *for mail*, 7 Gillette St.
COOK, Chas. B. (A'13), V. P., Charge Prod., Royal Typewriter Co., Inc., 150 New Park Ave.
COOPER, Geo. H. ('16; '35), 209 Fairfield Ave.
DART, Harry E. ('17), Asst. Secy., Hartford Steam Boiler Inspc. & Ins. Co., 56 Prospect St.
DORSEY, Francis E. (J'33), Asst. Lehr Engr., Hartford-Empire Co., 333 Homestead Ave.; *for mail*, 215 Sigourney St.
DOW, Richard F. ('21), Ch. Draftsman, Whitney Mfg. Co., Bartholomew Ave.; *for mail*, 162 Edgewood St.
DOWD, Bernard J. ('13; '16), Factory Supt., Royal Typewriter Co., Inc., 150 New Park Ave.
FALK, Geo. E. (J'34), Draftsman, Specification Dept., Veeder-Root, Inc., 20 Sargeant St.; *for mail*, 107 Edwards St.
FAZIOLI, Jeremiah J. (J'31), 34 Beach St.
FERGUSON, Wm. ('32), Asst. Supt., Engrg. Dept., Travelers Indemnity Co., 700 Main St.
FISH, Edwards Russell ('14; F'36), Manager, '23-'26; Vice-President, '26-'28; Ch. Engr., Boiler Div., Hartford Steam Boiler Inspc. & Ins. Co., 56 Prospect St.
FLYNN, Michael H. ('13), State Procurement Officer, U. S. Treasury Dept., State Procurement Office, 1044 Chapel St., New Haven; *for mail*, 113 Whitney St., Hartford.
GALE, Philip B. ('31), Chmn. of Bd., Stand. Screw Co., 476 Capitol Ave.
GATES, Clarence S. ('29; '35), Supt., Allen Mfg. Co., 133 Sheldon St., Hartford; *for mail*, 83 Fennbrook Rd., W. Hartford.
GIARDI, Libero A. (J'36), 307 Market St.
GILBERT, Carl L. (J'27), Adjuster, Hartford Steam Boiler Inspc. & Ins. Co., 56 Prospect St.
GOODWIN, Jas. L. ('22), V. P., Treas., Whitlock Coil Pipe Co.; *for mail*, 880 Asylum Ave.
HADDAD, Jos. (J'34), Prod. Apprentice, Underwood Elliott Fisher Co., 555 Capitol Ave.; *for mail*, 315 Pearl St.
HAINES, Donald O. (J'34), Inspc., Equip. Serv. Maint., Conn. State Highway Dept., 165 Capitol Ave., Hartford; *for mail*, 180 Hartford Ave., Wetherfield.
HALE, Frank W. (J'36), Pratt & Whitney Div., Niles-Bement-Pond Co., 436 Capitol Ave.; *for mail*, 35 Niles St.
HALL, Herman S. ('21; '35), State Supvr. of Trade & Vocational Education, State Bd. of Education, Hartford; *for mail*, 22 Coolidge St., New Britain.
HALSEY, Wm. D. ('16; '18; '23), Asst. Ch. Engr., Boiler Div., Hartford Steam Boiler Inspc. & Ins. Co., 56 Prospect St., Hartford; *for mail*, 44 Westland Ave., W. Hartford.
HERRICK, Edson P. ('18; '20; '35), Prod. Mgr., Colts Pat. Fire Arms Mfg. Co.; *for mail*, 27 Allendale Rd.
HOAGLAND, Frank O. ('12), M. M., Pratt & Whitney Div., Niles-Bement-Pond Co., 436 Capitol Ave.
HOLMES, Turey B. (J'17), Pres., Treas., Holmes-Talcott Co., 609 Franklin Ave.
INGLE, Henry W. ('20; '35), Prod. Engr., Hartford-Empire Co., Homestead Ave., Hartford; *for mail*, 35 Giddings Ave., Windsor.
JACOBS, Ward S. ('97; '04), 70 Terry Rd.
KELLER, Richard D. (J'31), Pratt & Whitney Div., Niles-Bement-Pond Co.
LEEDS, B. L. (J'34), Draftsman, Underwood Elliott Fisher Co., 56 Arbor St.; *for mail*, 315 Pearl St.
LONG, Geo. Alex. ('14), Pres., Gray Tel. Pay Sta. Co., 16 Arbor St.
MARKERT, Edw. R. (J'34), 196 Russ St.
MENY, Jos. W. ('23), Designer, Whitney Mfg. Co., Bartholomew Ave.; *for mail*, 157 Sisson Ave.
MERCIER, Alonzo P. (J'34), 74 Edgewood St.
MERRILL, Donald G. (J'19), Engr., Charge Lehr Devel., Hartford-Empire Co, 333 Homestead Ave., Hartford; *for mail*, 534 Fern St., W. Hartford.
MERRITT, Jos. ('07), Pres., Treas., Gen. Mgr., Hartford Spec. Mchy. Co., 287 Homestead Ave.
MEYERS, Edw. C. (J'33), Apprentice, Mch. Tool Div., Pratt & Whitney Div., Niles-Bement-Pond Co., 485 Capitol Ave., Hartford; *for mail*, 306 South Ave., Bridgeport.
MORGAN, Donald K. (J'32), Jr. Engr., Charge Design & Devel., Hartford-Empire Co., 333 Homestead Ave., Hartford; *for mail*, 83 Woodrow St., W. Hartford.
MORHARDT, Frank W. ('18), Mech. Supt., Royal Typewriter Co., Inc., 150 New Park Ave.
MORRISON, J. P. ('16), Asst. Ch. Engr., Charge Inspc., Hartford Steam Boiler Inspc. & Ins. Co., 56 Prospect St.
MULLER, Richard O. ('13), Ch. Engr., Terry Steam Turbine Co., Terry Sq.
NEILSON, Fred'k C. (A'08), M. E., Whitlock Coil Pipe Co., Hartford; *for mail*, 19 Westland Ave., W. Hartford.
NELSON, Edwin F. ('29; '35), Business Mgr., Bd. of Education, 249 High St.
NOBLE, Kenneth B. ('25), Pres., K. B. Noble Co.; *for mail*, 71 Scarborough St.
PAINE, Walter S. ('18; '21), Mgr., Engrg. & Research Dept., Aetna Life Ins. Co., 151 Farmington Ave.
PARK, Richard B. (J'32), Jr. Engr., Research, Hartford-Empire Co., Homestead Ave.; *for mail*, 238 Laurel St.
PARRY, E. Mason ('18), M. E., Hartford Steam Boiler Inspc. & Ins. Co., 56 Prospect St.
PEILER, Karl E. ('27), Ch. Engr., Charge Engrg. & Devel., Hartford-Empire Co., Drawer 1620.
PERLEY, J. Dwight (J'36), Conn. State Employment Serv., 525 Main St.; *for mail*, 20 Townley St.
PETERSON, Johann G. ('18; '35), Gen. Mgr., Elec. Co., 94 Allyn St
PORTER, Lloyd J. ('29; '35; '35), Engrg., Travelers Indemnity Co.; *for mail*, 166 Sigourney St.
POWERS, Joseph Horton (J'31), 333 Homestead Ave.
REEVES, Edw. H. ('19; '20; '35), Super. of Statistics, Conn. Emergency Relief Comm., State Office Bldg., Hartford; *for mail*, Race Hill Rd., Madison.
RICE, Chas. D. ('07), V. P., Underwood Elliott Fisher Co., 581 Capitol Ave.
RICHARDSON, Chas. H. (J'35), 19 Willard St.
RICHARDSON, Thos. B. ('18; '25), Ch. Engr., Turbine & Eng. Div., Hartford Steam Boiler Inspc. & Ins. Co., 56 Prospect St.
SACHS, Jos. ('11), Ch. Engr., Colts Pat. Fire Arms Mfg. Co.
SCOFIELD, Leslie W. (J'32), Engr., Estimating & Survey, Metro. Dist., Bur. of Pub. Wks., Municipal Bldg.; *for mail*, 53 White St.
SHAFFER, Thos. G. ('19; '23), Pres., Thos. G. Shaffer, Inc., 49 Pearl St.
SHAW, Richard S. (J'35), Spec. Apprentice, Pratt & Whitney Div., Niles-Bement-Pond Co., Capitol Ave.; *for mail*, 68 Farmington Ave.
SMITH, Prescott A. (J'35), Cadet Engr., Pratt & Whitney Div., Niles-Bement-Pond Co., 436 Capitol Ave.; *for mail*, 167 Washington St.
SORENSEN, Harry A. (J'31), Grad. Student, Univ. of Mich., Ann Arbor, Mich.; *for mail*, 20 Barker St., Hartford, Conn.
SPAUNBURG, Harvey L. ('21; '26), Ch. Engr., Veeder-Root, Inc., Sargeant St.

STEVENS, Louis W. ('27), Wks. Mgr., Veeder-Root, Inc., 20 Sargeant St.
STOUT, John D. ('21), V. P., Terry Steam Turbine Co., Terry Sq.
TANNER, Hubert D. ('23), Sales Engr., Pratt & Whitney Div., Niles-Bement-Pond Co., Hartford; *for mail*, 37 Brunswick Ave., W. Hartford.
TAYLOR, Allyn Chandler (J'34), Engrg. Asst., Gas Distribution, Hartford Gas Co., 233 Pearl St.
TELLER, S. Jay ('21), Pat. Atty., Colts Pat. Fire Arms Mfg. Co., Hartford; *for mail*, 28 Cumberland Rd., W. Hartford.
THIEME, Otto ('22; '35), Factory Mgr., Underwood Computing Mch. Co., 56 Arbor St., Hartford; *for mail*, 25 Walbridge Rd., West Hartford.
TOWNSEND, Harry P. ('04; '25), Pres., M. E., H. P. Townsend Mfg. Co., 5 Chestnut St.
TRUEDSSON, Gosta R. (J'34), Engr., Charge Design & Prod., Ameroil Burner Mfg. Corp., 35 Canton St.; *for mail*, 1035 Maple Ave.
TYLER, Chas. C. ('97), Retired; 61 Scarborough St.
VAN ZELM, Henri B. ('23; '35), Cons. Engr., Rm. 507, 11 Asylum St.
VEEDER, Curtis H. ('88; '97), 1 Elizabeth St.
WADMAN, Harold A. ('25; '35), Engr., Hartford-Empire Co., 333 Homestead Ave., Hartford; *for mail*, Bloomfield Ave., Bloomfield.
WASHBURN, J. M. (J'21), Treas., Merrow Mch. Co., 28 Laurel St.
WASVARY, Rudolph Fred'k (J'35), 143 Woodland St.
WEISS, Clyde Howard (J'30), Clerk, Cost Acctg., Pratt & Whitney Aircraft Co., E. Hartford; *for mail*, 62 Oakland Terrace, Hartford.
WESSTROM, David B. (J'28), Engr., Reports & Recommendations, Travelers Indemnity Co., 700 Main St.; *for mail*, 22 Evergreen Ave.
WILLIAMS, Jas. ('19; '35), Shop Supt., Terry Steam Turbine Co.; *for mail*, 156 Vine St.
WINCHESTER, Marshall Hayden ('21; '27; '35), Engr., Inspc. & Engrg. Dept., Travelers Indemnity Co., Main St., Hartford; *for mail*, 945 Windsor Ave., Windsor.
YANOSIK, Andrew J. (J'34), Draftsman, M. H. Rhodes, Inc., 30 Bartholomew Ave.; *for mail*, 315 Pearl St.

JEWETT CITY, Norwich Section

JOHNSON, Philip A. (A'30), Pres., Treas., Aspinook Co., Jewett City; *for mail*, Norwichtown.

KENT, Waterbury Section

BRASHER, Philip ('19), Gen. Mgr., Rex Brasher Associates.

MANCHESTER, Hartford Section

CHENEY, Frank, Jr. ('15), Retired; 20 Hartford Rd.
NICKERSON, J. W. ('11; '20), Div. Research, Cheney Bros.; *for mail*, 209 Pine St.
TREAT, Robt. M. (J'34), M. E., Charge Maint., & Mch. Devel., Rogers Paper Mfg. Co.; *for mail*, 113 E. Center St.

MERIDEN, Meriden Section

FLAGG, Chas. N., Jr. ('15), Pres., C. N. Flagg & Co., Inc., 79 Griswold St.
HUTCHINSON, John A. ('16; '21), Ch. Engr., Internatl. Silver Co., 48 State St.
STETSON, Ralph W. (J'21), Struc. Designer, N. Y., N. H. & H. R. R. Co., Meadow St., New Haven; *for mail*, 26 Converse Ave., Meriden.

MIDDLETOWN, Meriden Section

BACON, Chas. B. (J'30), Estimating, Bacon Bros., 359 Main St.; *for mail*, Newfield St.
WILLIAMS, Geo. M. ('21; '35), Pres., Gen. Mgr., Russell Mfg. Co.

MILFORD, New Haven Section

HEMPSTEAD, C. A. (J'34), 13 W. Main St.
HUNT, Wm. F. ('94; A'03), Life Associate.
LAKE, Simon ('07), Pres., Lake Submarine Co.

NAUGATUCK, Waterbury Section

ANDERSON, Harry Alfred ('36), Plant Engr., Charge Engrg. & Maint., U. S. Rubber Products, Inc., 58 Maple St.; *for mail*, 24 Salem St.
BUSHNELL Lester P. (J'36), Indus. Engr., U. S. Rubber Products, Inc.; *for mail*, 8 Carroll Court.
MULLER, Edw. S. (J'35), Naugatuck Chem. Co.; *for mail*, 32 Walnut Terrace.
PAYNE, Sheldon F. ('07), Cons. M. E., G. I. R. Glove Mfg. Co.; *for mail*, 32 Spencer St.
PEPPERMAN, Carl W. (J'32), Production Exec., U. S. Rubber Products, Inc., Maple St.; *for mail*, 72 Cherry St.
WENDES, John C. H. ('28), Cons. Engr., Charge Devel. & Design, Naugatuck Chem. Div., U. S. Rubber Products, Inc.; *for mail*, 260 Hillside Ave.

NEW BRITAIN, New Britain Section

BARNES, Herbert C. ('21), Cons. Engr., P. & F. Corbin Div., Am. Hardware Corp.; *for mail*, 18 Cedar St.
BAUER, Peter W. ('21; '27; '35), Drafting Dept. Head, Asst. to Dir., State Trade Sch., S. Main St.; *for mail*, 100 Slater Rd.
BROWN, Robt. Stanley ('91; '04), Life Member; Secy., Engr., New Britain Mch. Co., Chestnut St.; *for mail*, 29 Russell St.
BRUEMMER, Chas. H. ('20), Mfg. Engr., P. & F. Corbin Div., Am. Hardware Corp.; *for mail*, 10 Madison St.
FAIRFIELD, Wallace M. (J'34), 23 Park Pl.
GOSS, Stanley T. ('14), Pres., Goss & DeLeeuw Mch. Co.
GRISE, Romeo A. ('24), Plant Engr., Russell & Erwin Mfg. Co., 108 Washington St.; *for mail*, 140 Lafayette St.
GUSTAVSEN, John Arthur (J'35), Machinist, Stanley Elec. Tool Co., Elm St.; *for mail*, 19 Bassett St.
HART, Howard S. ('03), Chmn. Bd., Hart & Cooley, Inc.
HJERPE, Norman F. (J'32), V. P., Charge Engrg. Sales, C. A. Hjerpe Co., 73 Arch St.; *for mail*, 93 Winthrop St.
LEWIS, Brayton S. ('19), Supt., Tool & Die Depts., Stanley Wks., Lake St.
NOBLE, Wm. J., Jr. (J'30), Draftsman, Stanley Wks., Lake St.; *for mail*, 748 W. Main St.
NORRIS, Chas. H. ('13), M. E., Asst. to V. P., Am. Hardware Corp., Franklin Sq.
PATTERSON, Francis (J'33), Fafnir Bearing Co.; *for mail*, 6 Lake Court.
PELTON, Ernest W. ('13), Gen. Supt., Stanley Wks.; *for mail*, 77 Forest St.
POTTER, Howell LeRoy (J'32), Product Engr., Fafnir Bearing Co.; *for mail*, 125 Kelsey St.
ROGERS, Paul K. (A'34), Pres., Treas., Skinner Chuck Co., 344 Church St.
SCOTT, Alex. H. ('20), Supt. & Asst. Secy., New Britain Gas Light Co., 25 W. Main St.; *for mail*, 339 Hart St.
STANLEY, A. W. ('93; '03), Pres., Stanley Securities Co., P. O. Box 1133.
STEINKE, Oscar F. (J'33), Tool & Gage Maker, Pratt & Whitney Div., Niles-Bement-Pond Co., Capitol Ave., Hartford; *for mail*, 76 Prospect St., New Britain.
TUTTLE, Paul W. (J'32), Mch. Parts Inspc., New Britain-Gridley Mch. Co., Chestnut St.; *for mail*, 25 Hawley St.

NEW CANAAN, Bridgeport Section

BANCROFT, Chas. F. ('11), Ferris Hill Rd.
GREENE, Lawrence S. (J'25).
RADFORD, G. S. ('15), Cons. Engr., P. O. Box 426.
WILT, Abram D., Jr. ('13), Cons. Prod. Engr.

NEW HARTFORD, Hartford Section

WATSON, Frank (J'93).

NEW HAVEN, New Haven Section

ANTHONY, Richard L. ('35; '35), M. E., Westcott & Mapes, Inc., 139 Orange St., New Haven; *for mail*, 135 Filbert St., Hamden.
ARNOLD, Arthur A. ('17), Ch. Engr., A. C. Gilbert Co., New Haven; *for mail*, 56 Greenway St., Hamden.
BACON, David L. (J'17), M. E., Griest Mfg. Co., Blake St.
BARKER, Edw. L. ('27; '35), Mgr., E. L. Barker Co., P. O. Box 130, New Haven; *for mail*, 162 Glen Pkwy., Hamden.
BARNUM, Geo. S. ('87), Pres., Treas., Bigelow Co., Lloyd & River Sts.
BARNUM, Starr H. ('12; '16; '35), V. P., Secy., Bigelow Co., Lloyd & River Sts.
BENNETT, Harold M. ('28; '35), M. E., Devel. & Appl. Air Conditioning Equip., Safety Car Htg. & Ltg. Co., New Haven; *for mail*, 13 Chidsey Ave., E. Haven.
BOAK, Thos. I. S. ('22), Factory Mgr., Winchester Repeating Arms Co., 275 Winchester Ave., New Haven; *for mail*, 235 Hartford Turnpike, Hamden.
BRECKENRIDGE, Andrew L. ('13; '24; '35), Constr. Supervision, 1109 Chapel St.; *for mail*, 407 Dixwell Ave.
BREITENSTEIN, Albert F. ('19; '21), Wks. Mgr., Geometric Tool Co., Blake & Valley Sts.; *for mail*, 154 McKinley Ave.
BROOKE, H. St. George (J'35), 88 Cold Spring St.
BUXBAUM, Wm. ('17; '20), Planning Supt., Winchester Repeating Arms Co.; *for mail*, 422 Whitney Ave.
CASPELL, Edwin E. (J'32), Gen. Foreman, Wire Rope Dept., Am. Steel & Wire Co.; *for mail*, 48 Stuyvesant Ave.
COCHRAN, Frank John (J'36), 370 N. Front St.
DUDLEY, Saml. Wm. ('04; '16), Manager, '36-'39; Dean, Sch. of Engrg. & Chmn., Dept. M. E., Yale Univ., Mason Lab., 400 Temple St.
DUNCAN, Wm. Yeats, Jr. ('21; '26), Sales Engr. East Dist., Akron-Stand.-Mold Co., 1624 Englewood Ave., Akron, Ohio; *for mail*, 62 Cleveland Rd., New Haven, Conn.
DUNLOP, Chas. W. ('29), Mgr., Safety Car Htg. & Ltg. Co. & Pintsch Compressing Co.; *for mail*, 31 Marvel Rd.
EATON, Geo. H. ('32; '35), Engr., Charge Heating & Power, Foskett & Bishop Co.; *for mail*, 996 Whalley Ave.
ENGLISH, Philip H. (A'28), Treas., New Haven Clock Co.
FISHER, Henry D. ('07; '14), Treas., New Haven Pulp & Board Co., 259 East St.
FITTON, Wm. H. B. (A'22), Ch. Engr., Yale Univ. Power Station: *for mail*, 81 Audubon St.
FRANZ, Fred'k ('19; '28), Cons. M. E., 401 Chapel St.
GAYLORD, William W. ('14; '19; 26), Cons. Engr., 24 Harmon St.
GRACE, Chas. T. (J'36), Asst. & Grad. Student, Yale Univ., Mason Lab.; *for mail*, 51 Prospect St.
HODGE, Robt. J. ('31; '35), Asst. Treas., Gen. Mgr., Am. Buckle Co., 291 Campbell Ave., New Haven; *for mail*, 101 Connecticut Ave., W. Haven.
HOLMES, Geo. R. ('22; '25; '35), Pres. & Treas., McLagon Fdy. Co., 100 Audubon St.
HOOK, Jas. W. ('12; '14; '35), Pres., Treas., Geometric Tool Co., Blake & Valley Sts.
HULSE, Geo. E. ('20), Ch. Engr., Safety Car Htg. & Ltg. Co., Box 904, Dixwell Ave.
KEATOR, Frederic W. ('22; '26; '30), Asst. Prof. M. E., Sheffield Scien. Sch., Yale Univ., 400 Temple St.
LEETE, Wm. T. (J'34), 131 Cottage St.
LICHTY, Lester C. ('21; '30), Assoc. Prof. M. E., Yale Univ., 400 Temple St.
MACARTHUR, Robt. (A'04), Htg. Engr., New Haven Gas Light Co., 80 Crown St., New Haven; *for mail*, Johnson Rd., Woodbridge.
MARSH, John D. ('24; '35), Supt., Mason Lab., Sheffield Scien. Sch., Yale Univ., 400 Temple St.
MUNROE, Henry F. (J'34), Box 1966.
NEWTON, Wm. Geo. ('27), Supt., Peck Bros. & Co., 127 Chestnut St.; *for mail*, 809 Townsend Ave.
NORCROSS, J. Arnold ('00), Life Member; Cons. Engr., 421 St. Ronan St.
NORTH, Richard A. (J'21), Ch. Engr., Charge Product Design & Plant Maint., Farrell-Birmingham Co., Inc., Ansonia; *for mail*, 150 Westwood Rd., New Haven.
PARSELL, Roy L. ('27), Pat. Dept., Winchester Repeating Arms Co., New Haven; *for mail*, P. O. Box 524, Branford.
PASCALE, John A. (J'30), Mgr. & Dir., Northeastern Mch. Co., 486 Congress Ave.; *for mail*, 233 Forbes Ave.
POLLEYS, Herbert R. ('28), M. E., Devel. Wk., U. S. Rubber Products, Inc., Naugatuck; *for mail*, 304 Central Ave., New Haven.
PRESTON, Frank W. (J'25), Asst. Plant Engr., New Haven Pulp & Board Co., 259 East St.
RADECKI, Michael J. ('30; '35), Supt., Henry G. Thompson & Son Co., 277 Chapel St.
SCOTT, Chas. F. ('11), Emeritus Prof. E. E., Sheffield Scien. Sch., Yale Univ.
SEELEY, Lauren E. ('25; 31), Asst. Prof., Yale Sch. of Engrg., 400 Temple St.
SEWARD, Herbert L. ('12; '14; '18), Prof. M. E., Yale Univ., 211 Strathcona Hall; *for mail*, 794 Townsend Ave.
SHOEMAKER, Perry M. (J'28), 1960 Chapel St.
SKOGLUND, Victor J. (J'36), Teaching Asst. M. E., Yale Univ., 406 Strathcona Hall.
STARR, M. Orlando (J'35), Fellow in Transportation, Yale Univ. Graduate Sch.; *for mail*, 118 Mansfield St.
TAYLOR, Carl W. ('27), Secy., Asst. Ch. Engr., Westcott & Mapes, Inc., 139 Orange St.
THOMAS, Elmer E. (A'26), 1294 Whalley Ave.
THOMPSON, Willis F. ('19; '24; '30), Asst. Secy. & M. E., Westcott & Mapes, Inc., 139 Orange St.
TOWNSEND, Walker ('25; '35), Asst. Inspr., Conn. State Highway Dept., 535 Whalley Ave., New Haven; *for mail*, Middlesex Rd., Darien.
TRUMPLER, Paul R. (J'36), Grad. Student, Yale Univ., 2799 Yale Sta.
VANDERVEER, Martin ('24), Plant Engr., Hygienic Ice Corp., 881 State St.; *for mail*, 14 Eldridge St.
VINTEN, Ernest S. ('19), M. E., Sargent & Co.; *for mail*, 367 Edgewood Ave.
VON OHLSEN, Louis H. ('21; '25; '35), Asst. Engr., Charge Design, Test & Inspc., Safety Car Htg. & Ltg. Co., Dixwell & Putnam Aves.; *for mail*, 42 Vista Terrace.
WATERS, Everett O. ('14; '25; '35), Assoc. Prof. M. E., Yale Univ.
WELTER, Gustave ('22; '35), Asst. V. P., Charge Engrg. & Design, Bigelow Co., Box 706; *for mail*, 670 Winthrop Ave.

WESTCOTT, Harry R. ('16; F'36), Manager, '31-'34; Vice-President, '34-'36, and '37; Pres., Westcott & Mapes, Inc., 139 Orange St.
WHEELER, Gardner E., Jr. (J'36), Student Engr., Testing Dept., Gen. Elec. Co., Schenectady, N. Y.; *for mail,* 64 Marvel Rd., New Haven, Conn.
WINTHORPE, Jas. ('24; '35), Gen. Supt., Bigelow Co., River & Lloyd St., New Haven; *for mail,* 87 Bradley Ave., E. Haven.
WISE, Daniel E. (J'36), Lab. Asst. M. E., Yale Univ., 400 Temple St.
WOHLENBERG, Walter J. ('17; '25), Prof. M. E., Sheffield Scien. Sch., Yale Univ., Mason Lab.

NEW LONDON, Norwich Section

BEANEY, Walter E. ('30; '35), Ch. Engr., Turbine Div., D. E. Whiton Mch. Co., 96 Howard St.; *for mail,* 37 Crest St.
BROWN, Cecil W. ('15; '35), Ch. Engr., Conn. Power Co., 31 Union St.
ENGLISH, Fred S. ('22), Ch. Engr., Charge Design, Babcock Ptg. Press Mfg. Co., Pequot Ave.; *for mail,* 45 Squire St.
NIBBS, Ernest ('28), Ch. Engr., Elec. Boat Co., Groton; *home address,* 571 Ocean Ave., New London.
O'KEEFE, G. F. (J'36), Lieut., U. S. N., U. S. S. R-14, Submarine Base.
WHITON, Lucius E. ('05), Pres., Treas., D. E. Whiton Mch. Co., 190 Howard St.; *for mail,* 836 Pequot Ave.

NIANTIC, Norwich Section

WALL, Wm. C. ('20; '35), Engr., Conn. State Farm for Women.

NORWALK, Bridgeport Section

DUNTZE, John A. (J'30), Rubber Testing Dept., E. Norwalk Lab., R. T. Vanderbilt Co., E. Norwalk.
GALLAHER, Edw. B. ('19), Gen. Mgr. & Secy.-Treas., Clover Mfg. Co.
HUGGER, Richard (J'24), Ch. Engr., Clover Mfg. Co.; *for mail,* George Ave.
LANE, Harold G. (J'25), Prod. Engr., Clover Mfg. Co., Main St.; *for mail,* 12 Newtown Terrace.
LIBBY, Clarence R. (J'28), Engr., Nash Engrg. Co., Wilson Ave., S. Norwalk; *for mail,* 10 Glendening St., Norwalk.
MACK, Fred'k F. (J'30), Pat. Atty., Wm. F. Feyrer, 463 West Ave.
SHERRON, John (J'34), Spec. Apprentice, Maint. of Equip., Pa. R. R., Philadelphia, Pa.; *for mail,* 178 Main St., Norwalk, Conn.
SNIFFEN, Wm. H. ('20; '35), 16 Pershing St.

NORWICH, Norwich Section

BARBER, Clarence E. ('30; '35), Ch. & Constr. Engr., Norwich State Hospital; *for mail,* 213 Laurel Hill Ave.
FENTON, Thos. A., Jr. (J'29), Indus. Engr., U. S. Finishing Co.; *for mail,* 43—12th St.
MOODIE, Andrew ('30; '35), M. E., Power & Maint., Falls Co., Yantic St.; *for mail,* 12 Town St.
RANG, Eugene ('30; '35), Inspr., Hartford Steam Boiler Inspc. & Ins. Co., 56 Prospect St., Hartford; *for mail,* 466 Main St., Norwich.

OLD GREENWICH, Bridgeport Section

GRANT, Wm. W. ('35; '35), Indus. Mgmt. Engr., Barrington Associates, Inc., 220 E. 42nd St., New York, N. Y.; *for mail,* 41 Center Dr., Old Greenwich, Conn.
HODGES, Milton E. ('34; '35), Research Engr., Electrolux, Inc., Forest Ave.
LOFGREN, G. E. ('26; '35), Ch. Engr., Electrolux, Inc., Forest Ave.

ORANGE, New Haven Section

CARTER, Howard S. (J'30), Toolmaker, H. C. Cook Co., 28 Beaver St., Ansonia; *for mail,* "Hillcrest," Orange.

PLAINVILLE, New Britain Section

BERGAN, Martin P. (J'32), Draftsman, Fafnir Bearing Co., Booth St., New Britain; *for mail,* 47 E. Broad St., Plainville.
NORTON, Chas. H. ('13), Cons. Engr., Norton Co. of Worcester, Mass.; *for mail,* Sharpenhoe, Plainville, Conn.

PLANTSVILLE, Meriden Section

BAYRER, L. Garfield ('18), Wks. Mgr., Blakeslee Forging Co.
PERSIANI, Chas. C. (A'16), Retired; Clark Bolt Co.; *for mail,* Cowles Ave.

PORTLAND, Meriden Section

CRAFTS, Irving M. ('34), V. P., Gen. Mgr., Pickering Governor Co.; *for mail,* 485 Main St.

RIDGEFIELD, Bridgeport Section

MURPHY, Thos. R. H. ('11; '16; '35), Cons. Engr., Mead Investment Co., Dayton, Ohio; *for mail,* R. F. D. 1, Ridgefield, Conn.

RIVERSIDE, Bridgeport Section

HUNT, Edw. Eyre ('22), Bookhouse.
RIDABOCK, Jas. H. (J'30).

SAUGATUCK, Bridgeport Section

VOGT, Clarence W. ('15; '23), Pres., Inabag, Inc., 589 Riverside Ave.

SEYMOUR, Waterbury Section

BURHOE, Lemuel N. ('27), Plant Engr., Seymour Mfg. Co., Franklin St.; *for mail,* 25 Pershing Ave.
CLAPP, Lawrence R. ('21), V. P., New Haven Copper Co.

SHARON, Waterbury Section

THURSTON, Edw. D., Jr. ('09; '12), Retired.

SHELTON, New Haven Section

DIEFENBACH, John S. (J'35), Asst. Prod. Mgr., Shelton Tubular Rivet Co.
WEIMANN, Alfred F. ('31), 27 Edgewood Ave.
WIBERG, Carl B. (J'30), Sales Engr., OK Tool Co., Shelton; *for mail,* 77 Richardson St., Bridgeport.

SIMSBURY, Hartford Section

HAMILTON, Wm. Floyd ('27; '34; '35), Ch. Engr., Ensign-Bickford Co.

SOUTHINGTON, Meriden Section

RALSTON, Albert Edw. (J'35), Cost Estimator, Beaton & Corbin Mfg. Co., N. Main St.; *for mail,* 98 Meriden Ave.

SOUTH MANCHESTER, Hartford Section

MALLORY, Henry R. ('33), Comptroller, Cheney Bros.; *for mail,* P. O. Box 27.

SOUTH NORWALK, Bridgeport Section

ADAMS, Harold E. ('30), Ch. Engr., Nash Engrg. Co.
GOLDSBOROUGH, Winder E. ('15), Cons. Engr.
GRAY, G. Francis ('19), Pres., Gray Elec. Corp., Day & Concord Sts.; *for mail,* 25 Bayview Ave.
HOWELL, John D. (J'33), Draftsman & Designer, Nash Engrg. Co., S. Norwalk; *for mail,* 6 Orchard St., Norwalk.
JENNINGS, Irving C. ('08; '15; '18), Pres., Nash Engrg. Co., Wilson Rd.
MATHEWS, Wm. E. ('95), Cons. Engr., 158 Flax Hill Road.
NASH, Douglas E. ('17; '35), Treas., Nash Engrg. Co., Wilson Ave.
STOLL, John, Jr. ('16; '26; '35), Draftsman, Nash Engrg. Co., Wilson Ave., S. Norwalk; *for mail,* 444 Thompson St., Stratford.
WYLIE, Howard M. (J'12), V. P., Charge Design & Sales, Nash Engrg. Co.

SPRINGDALE, Bridgeport Section

McCUE, Jas. O. ('26), Pres., Stamford Rolling Mills Co.

STAMFORD, Bridgeport Section

BABCOCK, Lawrence R. ('30; '36), Mgr., Natl. Serv. Dept., Petroleum Heat & Power Co.; *for mail,* 22 Glenbrook Rd.
BADEN, Carl A. ('24), Plant Engr., Norma-Hoffmann Bearings Corp., Hamilton Ave.
BATESOLE, Dwight E. ('20; '29), Asst. Engrg. Mgr., Norma-Hoffmann Bearings Corp.
BOTT, Geo. R. ('13), Ch. Engr., Norma-Hoffmann Bearings Corp.; *for mail,* 8 Howes Ave.
CHALMERS, John B. ('11; '18), Safety Engr., Dir. Training, Yale & Towne Mfg. Co., Henry St.; *for mail,* Miller's Bridge.
CHAPELL, Alex R. ('23; '30; '35), Designing Engrg., Postage Meter Co., Pacific St., Stamford; *for mail,* 51 North St., Milford.
DAVOL, Frank H., Jr. ('16), Hickory Dick.
DAY, Harry L. ('28; '35), Supt., Norma-Hoffmann Bearings Corp., Stamford; *for mail,* 33 Cowing Pl., Glenbrook.
EMERY, A. H. ('21), Pres., A. H. Emery Co., 682 Main St.
FRICKER, Jacob E. ('17; '35), Ch. Engr., Air Reduction Co., Inc., 60 E 42nd St., New York, N. Y.; *home address,* 3 Howes Ave., Stamford, Conn.
HILL, Ebenezer ('00; '07), "Single Oak," N. Stamford.
IVES, Geo. S. (J'35), 41 Forestlawn Ave.
JEHLE, Ferdinand ('13; '18; '26), Dir. of Labs., Hoffman Specialty Co., 575 Pacific St.
KEEVER, H. K. ('22; '30; '35), 5 Revonah Ave.
LANEY, Frank R. ('18; '28), Dir., Stamford State Trade Sch., Conn. State Bd. of Education.
LEWIS, Frank S. (36), Shick Dry Shaver, Inc., Stamford; *for mail,* 5 Abby Rd., Darien.
MARSHALL, Wm. ('29; '30; '35), Tool Rm. Foreman, Norma-Hoffmann Bearings Corp., Stamford; *for mail,* 9 Plymouth Rd., Glenbrook.
MAXWELL, Maxwell C. ('08), Asst. to the President, Yale & Towne Mfg. Co.
MESINGER, Fred'k W. ('24; '29), N. Y. Dist. Mgr., Norma-Hoffmann Bearings Corp., Stamford; *for mail,* Glenbrook.
MOEBIUS, H. G. (J'30), Reed Pl., R. F. D. 1.
MOODY, Richard C. ('30; '35), Engr., Charge Tests, Petroleum Heat & Power Co., Stamford; *for mail,* 88 Knapp St., Springdale.
NORVIG, Irvin E. (J'34), Indus. Dryer Corp., 432 Fairfield Ave.
OLIND, John H. (J'21), Factory Engr., Hookless Fastener Co., Meadville, Pa.; *for mail,* 80 Plymouth Rd., Stamford, Conn.
SCHLITT, J. L. (J'19), Air Reduction Co., 41 McGee Ave., Stamford; *for mail,* Christy Hill Rd., Darien.
TATE, Malcolm C. (J'29), M. E., A. H. Emery Co., 682 Main St.
TRUAX, Wm. H. ('18; '35), Mgr., Stamford Office, State Employment Serv., Labor Dept., State of Conn., 308 Atlantic St.; *for mail,* 32 Arlington Rd.
VAUGHN, Wm. M. ('23), Ch. Engr., Stamford Gas & Elec. Co.; *for mail,* 447 Shippan Ave.
WICKS, Clifford P. ('21; '29), Ch. Product Draftsman, Yale & Towne Mfg. Co., 200 Henry St.; *for mail,* 60 Hoyt St.

STORRS, Norwich Section

EDEL, Walter L. ('21; '26; '29), Dean of Engrg., Conn. State College.
PHELPS, Chas. W. ('28; '34; '35), Instr. M. E., Conn. State College, Box 17.

STRATFORD, Bridgeport Section

DARLING, Philip G. ('06; '12), 1451 S. Main St.
GALLAGHER, Leo H. (J'35), Box 490, Nichols Ave.

THOMASTON, Waterbury Section

BENNETT, Clark G. ('23), Retired; Box 245.
FARRELL, Jos. V. ('23; '25; '35), Engr., Tower Clock Design, Seth Thomas Clock Co.; *for mail,* Walnut St.
HUTT, Arthur R. (J'35), Engr., Time Study, Seth Thomas Clock Co.

THOMPSONVILLE, Hartford Section

BAUER, Ernest K. ('31; '34; '35), Engr., Mch. Design, Bigelow-Sanford Carpet Co.; *for mail,* 57 Garden St.
RIDLEY, Earl L. ('29; '35), Plant Engr., Charge Maint. & Power, Bigelow-Sanford Carpet Co., Main St.; *for mail,* 1104 Enfield St.

TORRINGTON, Waterbury Section

BLAKESLEE, Howard R. ('18; '35), M. M., Hendey Mch. Co., 105 Summer St., Torrington; *for mail,* P. O. Box 151, Thomaston.
BRILL, Elliot M. ('18; '26), Engr., Charge Time Study, Union Hardware Co., 535 Migeon Ave., Torrington; *for mail,* Box 403, Winsted.
PERRY, Ralph H. ('15; '21; '35), Supt., Progressive Co., 52 Norwood St.
STORRS, Robt. S. ('23), V. P., Charge Engrg. & Sales, Torrington Mfg. Co., 70 Franklin St.

VERSAILLES, Norwich Section

HOLM, Lovelock ('30; '35), Ch. Engr., Charge Power Equip., Inland Paper Bd., Inc., Versailles; *for mail,* 12 Harland Rd., Norwich.

WALLINGFORD, Meriden Section

CRAIN, John J. ('96; '08), E. Main St.

WASHINGTON DEPOT, Waterbury Section

FENN, Edw. P. (J'28).

WATERBURY, Waterbury Section

ASHLEY, Henry C. (J'34), Engr. of Tests, Chase Brass & Copper Co., Inc., 236 Grand St.; *for mail,* 39 Euclid Ave.
BEAN, Lawrence G. ('20; '26; '35), Sales Mgr., Bristol Co.; *for mail,* 158 Fiske St.
BRISTOL, Howard H. ('13; '25), Pres., Bristol Co.
CAMPBELL, L. Barrett ('21), Designing Engr., Andrew C. Campbell Div., Am. Chain Co., Bridgeport; *for mail,* 186 Hillside Ave., Waterbury.
CARTER, Frederick W. ('20), 65 Bonair Ave.
CHASE, Fred'k S. ('14), Pres., Chase Brass & Copper Co., Inc., 236 Grand St.
CHASE, L. Alvin (J'34), Superior Ave.
CHASE, Roger C. (J'36), 36 Superior Ave.
CHILDS, C. Walter ('22), Mech. & Constr. Engr., Scovill Mfg. Co., 99 Mill St.; *for mail,* 25 Steuben St.

COE, John A. ('24), Pres., Am. Brass Co., 414 Meadow St.; *for mail*, 493 Willow St.
DALY, Edmund J. ('26), Pres., Gen. Mgr., M. J. Daly & Sons, Inc., 541-575 Bank St.
DAVIS, Alvan L. ('26), Research Engr., Scovill Mfg. Co., 99 Mill St.; *for mail*, 25 Concord St.
DEMPSEY, Michael J. ('16; '25), Mech. Supt., Chase Brass & Copper Co., Inc., Grand St.: *for mail*, 48 Clifton Ave.
DILLON, Harold J. (J'34), 802 Hamilton Ave.
DOOLITTLE, Warren P. ('12; '14; '21), Engr., Charge Mch. Tool Dept., Waterbury Brass Goods Branch, Am. Brass Co., 26 Crane St.; *for mail*, Hillcrest, R. F. D. 3.
EGAN, Harold J. (J'29), Instr., Training Dept., Scovill Mfg. Co.; *for mail*, 90 Willow St.
ELLIS, Arthur Louis ('31), Sales Engr., Waterbury Tool Co., E. Aurora St., Waterbury; *for mail*, Box 122, Deep River.
FIEGE, Henry J. ('20; '27), Foreman, Charge Mchy. Bldg., Waterbury Farrell Fdy. & Mch. Co., Bank St.; *for mail*, 1171 W. Main St.
FORMAN, Walter W. ('29; '35), Gen. Engr., Conn. Light & Power Co.
FRENCH, Fred W. ('29), Pres., French Mfg. Co.; *for mail*, 72 Hale St.
GERMAN, A. J. ('21), Ch. Engr., Scovill Mfg. Co.; *for mail*, 23 Evans St.
GOSS, Edw. O. ('89; '06), Pres., Scovill Mfg. Co.
GRANGER, C. H. (A'32), V. P. & Gen. Mgr., Charge Prod. & Sales, Ingersoll-Waterbury Co., 31 Cherry Ave.
HALL, Willis M. ('27), Plant Engr., Plume & Atwood Mfg. Co.; *for mail*, 160 Prospect St.
HART, Howard P. ('15; '25), Asst. to Mgr., Platt Bros. & Co., P. O. Box 1030; *for mail*, 36 Buckingham St.,
HOLCOMB, Howard L. ('21; '35), Tool & Mch. Designer, Scovill Mfg. Co.; *for mail*, 173 Chipman St.
JOHNSON, Edw. W. ('92), 70 Chestnut Ave.
KELSEY, Jas. G. (J'36), 348 Highland Ave.
KIRSCH, C. Russell ('22; '30), Engr., Design, Devel. & Planning, Waterbury Mfg. Co. Div., Chase Brass & Copper Co., Inc., 236 Grand St.; *for mail*, 40 Melbourne Terrace.
KOESTER, Herman ('11; '13), V. P., Charge Mfg., Bristol Co.; *for mail*, 41 Columbia Blvd.
LEGGETT, Geo. R. ('12), Mech. Supt., Scovill Mfg. Co.; *for mail*, 81 Fiske St.
MABEY, Arthur R. ('16), Research Devel. Engr., Bristol Co.; *for mail*, 22 Farnham Ave.
MACLEAN, Donald (J'36), 647 Cooke St.
MARTUS, M. L. ('12), Pres., Gen. Mgr., Waterbury Battery Co., 1036 S. Main St.
McCONAHEY, Hugh M. (J'33), Asst. in Tech. Dept., Am. Brass Co., Waterbury; *for mail*, 39 Pleasant St., Ansonia.
PALATINE, Renard L. ('18; '25), Principal, Waterbury Continuation Sch.; *for mail*, 12 Elmwood Ave.
PAPE, Eric ('32; '35), Secy., Mech. Supt., Am.-Republican, Inc., 61 Leavenworth St.; *for mail*, 661 Willow St.
PERRIN, Danl. H. (J'33), 263 Cooke St.
PERRY, Rupert C. ('21; '35), M. E., Design, Ingersoll-Waterbury Co., Cherry Ave.; *for mail*, 195 Woodlawn Terrace.
PLATOU, Leiv S. ('36), Sales Engr., Waterbury Farrell Fdy. & Mch. Co., Waterbury; *for mail*, 61 Oakland Rd., Southington.
PURINTON, Forrest G. ('24), Engr., Charge Design, Patent Button Co., 41 Brown St.
PUTNAM, J. Russell ('13), Mech. Supt., Waterbury Clock Co.; *for mail*, 64 Woodside Ave.
RAUB, J. Heartt (J'34), Draftsman, Waterbury Farrell Fdy. & Mch. Co., Bank St.; *for mail*, 32 Kellogg St.
RIPLEY, E. Bradford, Jr. ('29; '35), Prod. Engr., Conn. Light & Power Co., 250 Freight St.
ROBERTS, Jos. H. ('22; '27), Senior Engr., J. H. Roberts & Associates, 33 W. Main St.; *for mail*, P. O. Box 1525.
RUSH, Chas. Wm. ('30), Plant Engr., Waterbury Mfg. Co., N. Main St.; *for mail*, 292 Bunker Hill Ave.
SANDERSON, E. S. ('95; '03), Sales Mgr., Scovill Mfg. Co.; *for mail*, 155 Buckingham St.
SCHNEIDER, Wm. ('30; '35), Asst. Supt., Waterbury Brass Goods Branch, Am. Brass Co., 26 Crane St.; *for mail*, 245 Country Club Rd.
SHAW, Richard, Jr. (J'33), Designer, Specialty Dept., Bristol Co.; *for mail*, 69 Linden St.
SHEWBRIDGE, W. H. (J'36), Mem. Training Course, Scovill Mfg. Co., 99 Mill St.; *for mail*, 127 Hillside Ave.
SHOEMAKER, R. W. ('36), Cons. Engr., Chase Brass & Copper Co., Inc., Waterbury; *for mail*, Orenaug Ave., Woodbury.
SIMPSON, Wm. K. ('09; '25), V. P., Hoffman Specialty Co., 193 Grand St.; *for mail*, 9 Sands St.
SINCLAIR, L. P., Jr. (J'34), Mem. Training Course, Scovill Mfg. Co., Mill St.; *for mail*, 133 Hillside Ave.
SOMERS, Dwight LeRoy (J'34), 136 Baldwin Ave.
SPERRY, Roger S. ('33), Supt., Admin. Research, Scovill Mfg. Co., 99 Mill St.
STEER, Donald E. (J'33), Machinist, Scovill Mfg. Co.; *for mail*, 179 Meriden Rd.
TAYLOR, Arthur L. ('30; '35), Asst. Mech. Supt., Scovill Mfg. Co., Waterbury; *for mail*, Pembroke Ave., P. O. Box 91, Waterville.
THOMPSON, Hugh L. ('94), Cons. Engr., 129 Pine St.
TYACK, G. N. (J'36), Mem. Exec. Training Course, Scovill Mfg. Co., Mill St., Waterbury; *for mail*, Main St., Cheshire.
WARNER, Chas. M. ('26), Foreman, Charge Wire Mill, Scovill Mfg. Co., 99 Mill St.; *for mail*, 430 Frost Rd.
WELLS, Gordon E. (J'36), Instrument Man, Bristol Co.; *for mail*, 292 W. Main St.
WILSON, Fred'k G. ('24; '26; '35), Prod. Supt., Waterbury Button Co., 835 S. Main St.; *for mail*, 34 Wildemere Ave.

WATERTOWN, Waterbury Section

ALVES, Alex. L. ('31; '36), Engr., Charge Estimating & Plant Mgmt., Watertown Mfg. Co.; *for mail*, Middlebury Rd.
SODERBERG, E. W. (J'35), Engr., Asst. to Mgr., Watertown Mfg. Co.

WEST HARTFORD, Hartford Section

AVERY, John R. (J'32), Planning Engr., Chance Vought Aircraft, Div. of United Aircraft Corp., E. Hartford; *home address*, 92 S. Quaker Lane, W. Hartford.
BELCHER, Warren J. ('14), Ch. Engr., Whitney Chain & Mfg. Co., 237 Hamilton St., Hartford; *for mail*, 784 Farmington Ave., W. Hartford.
BLOUNT, Geo. E. (J'34), 417 S. Quaker Lane.
ERB, Edmund M. ('18; '35), Ch. Engr., Hartford Spec. Mchy. Co., 287 Homestead Ave., Hartford; *home address*, 53 Lexington Rd., W. Hartford.
GROHMANN, Carl L. ('98), 21 Beverly Rd.
HONISS, Wm. H. ('99), Asst. Secy., Hartford-Empire Co., 333 Homestead Ave., Hartford; *for mail*, 141 Steele Rd., W. Hartford.
MEAD, Geo. Jackson ('21; '35), V. P., Ch. Engr., United Aircraft Corp., E. Hartford; *for mail*, P. O. Box 296, W. Hartford.
MORSS, Chas. A. ('26; '35), Inspr. Assembly & Test., Pratt & Whitney Aircraft Co., E. Hartford; *for mail*, 91 Ledyard R., W. Hartford.
TOWNSEND, Chas. D. (J'34), Exper. Engr., Capewell Mfg. Co., 60 Governor St., Hartford; *for mail*, 29 Bretton Rd., W. Hartford.
WOLCOTT, Henry A. ('97), Cons. Engr., New Britain Ave.

WEST HAVEN, New Haven Section

HALL, Alvin C. (J'36), 587 Washington Ave.

WESTPORT, Bridgeport Section

FARNHAM, Dwight T. ('18), Compo Rd.
MOGENSEN, Allan H. ('24; '33), Indus. Consultant, 330 W. 42nd St., New York, N. Y.; *for mail*, R. F. D. 2, Westport, Conn.

WILLIMANTIC, Norwich Section

WELCH, Albert E. ('20; '25), M. E., Charge Maint. & Power, Am. Thread Co., Main St.; *for mail*, 70 Pleasant St.

WILTON, Bridgeport Section

MICHELSON, John S. ('23; '35).

WINDHAM, Norwich Section

OMAN, Geo. E. (J'33), Mech. Inspr., Pratt & Whitney Aircraft Co., E. Hartford; *for mail*, S. Windham.

WINDSOR, Hartford Section

DICKINSON, Merton H. (J'36), 167 Park Ave.
SCHNEIDER, Wilfred C. (J'34), 21 Capen St.

WINDSOR LOCKS, Hartford Section

MATHER, Robt. H. ('22), 51 Elm St.
REGAN, Jos. C. ('11), Pres. & Gen. Mgr., E. Horton & Son Co.
SMITH, H. Pearson ('35; '35), Plant Engr., C. H. Dexter & Sons, Inc.

WINSTED, Hartford Section

WILLIAMS, Othenil G. ('31; '35), V. P., Wm. L. Gilbert Clock Corp., 276 N. Main St.

DELAWARE

EDGE MOOR, Philadelphia Section

COX, Frank G. ('05; A'08).
WILLIAMS, John D. (J'33), M. E., Charge Power, Ludlow Mfg. & Sales Co.

FREDERICA, Philadelphia Section

HAHN, Palmer L. (J'31), Ch. Forester, Del. Project, Charge Forestry, Wild Life; Asst. in Engrg. & Landscape, Resettlement Admin., Harrington; *for mail*, c/o Katie Boone, Frederica.

NEWARK, Philadelphia Section

LINDELL, W. Francis ('29; '33; '35), Asst. Prof., Univ. of Del.; *for mail*, 49 Prospect Ave.
MOODY, Arthur M. G. (J'35), Instr. M. E., Univ. of Del.
SPENCER, Robt. L. ('13; '20), Dean of Engrg., Univ. of Del.

NEWPORT, Philadelphia Section

NEWELL, Francis M. (J'33), Devel. Engr., Krebs Pigment & Color Corp., Newport; *for mail*, 614 Geddes St., Wilmington.

WILMINGTON, Philadelphia Section

ACKART, E. G. ('17), Ch. Engr., E. I. du Pont de Nemours & Co., Rm. 12076, du Pont Bldg.
AYER, Wm. T. ('16), Design Engr., Hercules Powder Co., Delaware Trust Bldg.
BALLENGER, Robt. O. (J'33), 2317 Tatnall St.
BELLANCA, Guiseppe M. ('30), Pres., Ch. Engr., Designer, Bellanca Aircraft Corp., New Castle; *home address*, R. F. D. 2, Rockland Rd., Wilmington.
BERGLAND, Wm. S. ('18; '35), Engr., Operative Engrg. Div., E. I. du Pont de Nemours & Co.
BICKNELL, Chas. Edmund (J'35), 218 W. 19th St.
BLUMBERG, Leo ('21; '27), Assoc. Prof. M. E., Univ. of Del., Newark; *for mail*, 4 E. 14th St., Wilmington.
BOND, Wm. G. ('28), P. O. Box 229.
BOYER, J. Rudolph (J'34), Engrg. Dept., E. I. du Pont de Nemours & Co.
BRADFORD, Wm. ('21), Sales Engr., Foster Wheeler Corp., Packard Bldg., Philadelphia, Pa.; *home address*, 1211 Gilpin Ave., Wilmington, Del.
BRENTLINGER, John M. ('17; '23), Head, Indus. Engrg. Div., E. I. du Pont de Nemours & Co., c/o Technical Library, du Pont Bldg.
BRIDGE, Theo. E. (J'31), Design Engr. (Power), E. I. du Pont de Nemours & Co.
BURR, Frank M. ('22; '35), Constr. Engr., E. I. du Pont de Nemours & Co.; *for mail*, 2132 Lancaster Ave.
CONVERSE, Bernard T. ('09), Cons. Engr., 817 Delaware Trust Bldg.
FULLER Jas. H. (J'36), 803 N. Harrison St.
GENEREAUX, Raymond P. (J'30), Research Chem. Engr., E. I. du Pont de Nemours & Co.
GIRVIN, Chas. J. ('94; '05), Bldg. Mgr., Y. M. C. A., 11th & Washington Sts.; *for mail*, 912 Franklin St.
GORNEY, Henry Stanley (J'33), Draftsman, Pusey & Jones Corp.; *for mail*, 724 E. 6th St.
HACKETT, Robt. S. (J'33), Indus. Engrg. Div., E. I. du Pont de Nemours & Co., Wilmington; *for mail*, 134—2nd St., New Castle.
HANEY, Harold B. (J'31), Engr., Charge Design, Haveg Corp., Marshallton; *for mail*, Y. M. C. A., 11th & Washington Sts., Wilmington.
HARDING, Philip O. ('21), Ch. Draftsman, Pyrites Co., Inc.; *for mail*, 802 Blackshire Rd.
HARKINS, H. Drake ('33), M. E., Charge Indus. Power, E. I. du Pont de Nemours & Co.
HEALD, Willard R. ('20; '30), Asst. Plant Supt., E. I. du Pont de Nemours & Co.; *for mail*, 721 Coverdale Rd.
HOLT, J. Hunt ('19; '21), 1813 Franklin St.
HOMEWOOD, William T. ('17; '21), Engr., Charge Power Design, E. I. du Pont de Nemours & Co., 13064 du Pont Bldg.
HOPE, Walter R. ('15; '22), Engr., Charge Design, E. I. du Pont de Nemours & Co., Market & 10th St.; *for mail*, 700 W. 20th St.
HUMME, F. H. (J'29), E. I. du Pont de Nemours & Co., Rm. 12166, du Pont Bldg.
JAUSS, August C. ('18; '35), Designing Engr., E. I. du Pont de Nemours & Co., Wilmington, Del.; *for mail*, 301 W. Providence Rd., Aldan, Delaware Co., Pa.
KLUTEY, Fred'k E. (J'25), Project Engr., Charge Design, E. I. du Pont de Nemours & Co., du Pont Bldg.; *for mail*, 719 Coverdale Rd.
LAFTMAN, Rickard N. (J'33), 4 Lore Ave.
LEWIS, Herschel Paul (J'30), Asst. Mgr., Safety & Fire Protection Div., E. I. du Pont de Nemours & Co., Wilmington; *for mail*, River Rd., R. F. D. 3, Bellevue Manor.
LIMONT, Alex. W., Jr. ('29), Project Engr., Dupont Engrg. Co.; *for mail*, 24 Bedford Court.
LOCKE, Walter ('30; '35), Asst. Ch. Engr., Edge Moor Iron Wks., Inc., Edge Moor; *for mail*, R. F. D. 3, Perkins Ave., Wilmington.
MAIER, Harry L., Jr. (J'33), Devel. Wk., Natl. Vulcanized Fibre Co.; *for mail*, 229 Connell St.
MAXFIELD, H. H. ('04), Supt. Motive Power, Pa. R. R. Co., 402 Pennsylvania Bldg.
MOLINARI, Wilfred H. (J'35), Jr. Area Engr., (M. E.), E. I. du Pont de Nemours & Co.; *for mail*, Y. M. C. A.
MOSBROOK, Jos. S. ('28; '35), Safety & Fire Protection Div., E. I. du Pont de Nemours & Co.
OSINSKI, Leon F. (J'31), Engr., Investigation Wk., Gen. Chem. Co., Marcus Hook, Pa.; *for mail*, 10 E. 2nd St., Wilmington, Del.

PHELAN, P. A. ('19), M. E., E. I. du Pont de Nemours & Co., Wilmington, Del.; *for mail,* 246 Congress Ave., Lansdowne, Pa.
PRATT, Thos. G. (J'29), Engr., E. I. du Pont de Nemours & Co.; *for mail,* 1017 Park Pl.
RAMER, Geo. E. ('22), Ch. Engr., Hercules Powder Co., 900 Market St.; *for mail,* 14 Broom.
RHOADS, Philip G. ('28; '35), Partner, Charge Prod., J. E. Rhoads & Sons, 11th St. & B. O. R. R.
ROBINSON, C. Stanley ('24; '31; '35), Engrg. Dept., E. I. du Pont de Nemours & Co.
ROSSEE, Christian (J'30), 1506 Delaware Ave.
SCHOENIJAHN, Robt. P. ('10; '16), Cons. Engr., 408 Industrial Trust Bldg.
SCHWERTFEGER, A. J. (J'33), Indus. Engr., Rm. 12054, E. I. du Pont de Nemours & Co.
SEGEL, Jos. ('21; '35), Indus. Power Engr., E. I. du Pont de Nemours & Co., 12060 du Pont Bldg.
SHAW, Benj. F., II (J'30), Pres., Benj. F. Shaw Co., 2nd & Lombard Sts.
SHAW, Jos. H. (J'14), Inspr., E. I. du Pont de Nemours & Co.
SHIMER, A. A. ('17), Dir. Opera., Naval Stores Dept., Hercules Powder Co., Delaware Trust Bldg.; *for mail,* 829 Harrison St.
SHOCKLEY, H. W. ('35; '35), Engrg. Dept., E. I. du Pont de Nemours & Co.
SILER, Lawrence Norman ('29; '35), Inspr. Power Plants, E. I. du Pont de Nemours & Co.
SMITH, Frank E. ('31), Ch. Engr., Mineral Separation Div., E. I. du Pont de Nemours & Co.; *for mail,* 2302 Baynard Blvd.
SMITH, Malcolm H. ('18; '35), Designer, E. I. du Pont de Nemours & Co.; *for mail,* 107 E. 28th St.
SMITH, Philip M. (J'34), Indus. Engr., Exper. Plant Engrg., E. I. du Pont de Nemours & Co.; *for mail,* 212 E. 16th St.
STANIAR, Wm. ('14; '16), M. E., Charge Mech. Power, E. I. du Pont de Nemours & Co., du Pont Bldg.
STEINS, Carleton K. ('21; '35), M. M., Pa. R. R. Co.; *for mail,* 2501 Madison St.
STEWART, Paul M. (J'35), Draftsman, Hercules Powder Co.; *for mail,* Y. M. C. A., 11th & Washington Sts.
STUART, Jos., 3d (J'36), 1022 Trenton Pl.
SUTTON, E. Clifton ('26), Designer, E. I. du Pont de Nemours & Co.; *for mail,* 1205 W. 7th St.
TALLMAN, Frank G. ('81), Manager, '05-'08; V. P. & Dir., E. I. du Pont de Nemours & Co., du Pont Bldg.
TAYLOR, A. Orville (J'35), Spec. Apprentice, M. E. Dept., Pa. R. R. Shops, Wilmington, Del.; *for mail,* 100 Morton Ave., D-104, Ridley Park, Pa.
VARNES, Saml. K. (J'10), Ch. Engr., Ammonia Dept., E. I. du Pont de Nemours & Co.; *for mail,* 2208 Boulevard.
VIOHL, Herbert K. W. ('23; '29; '35), Engr., Benj. F. Shaw Co., 2nd & Lombard Sts.; *for mail,* 100 Fulton St.
WARNER, Jacob L. ('17), Mgr. Charge Real Estate, E. I. du Pont de Nemours & Co., 10th & Market Sts.; *for mail,* 2308 W. 11th St.
WOOD, Herbert B. ('21; '35), M. E., E. I. du Pont de Nemours & Co., 10th & Market Sts.; *for mail,* 199 Brandywine Blvd.
YERZLEY, Felix L. (J'31), Physicist, Charge Physical Testing Rubber, E. I. du Pont de Nemours & Co., Box 525; *for mail,* 1405 Delaware Ave.
ZEISE, Kurt Siegfried (J'30), Mech. Draftsman, E. I. du Pont de Nemours & Co., du Pont Bldg., Wilmington; *for mail,* Arden.

YORKLYN, Philadelphia Section

CRONIN, Frank Howard ('17), M. E., Natl. Vulcanized Fibre Co.

DISTRICT OF COLUMBIA

WASHINGTON, Washington, D. C. Section

ADAIR, John G. ('22; '30), M. E., Bur. of Loco. Inspc., Interstate Commerce Comm., Constitution Ave. & 12th St.
ADAMS, Franklin S. ('24; '33), P. O. Box 1436.
ADELMAN, Arthur ('16), Ord. Engr., Ord. Dept., U. S. A., Rm. 3826, Munitions Bldg.; *for mail,* 3709 Military Rd.
ALBURGER, Harry A. (J'27), Assoc. Engr., Design Sec., Bureau of Ord., Navy Dept., 17th St. & Constitution Ave.; *for mail,* 3624 10th St., N. W.
ALLEN, David P. ('27), Engr. of Distribution, Washington Gas Light Co., 411—10th St., N. W.
ASHBY, Jas. C. ('28), Engr., Design & Specifications, Rural Electrification Admin., Washington, D. C.; *for mail,* Falls Church, Va.
BAKER, W. Kenneth (J'31), Jr. Engr., Ballistics, Bur. of Ord., Navy Dept.; *for mail,* 4550 Connecticut Ave., N. W.
BARKER, Gilbert E. ('26; '35), Sales Engr., Crane Co., 1225 Eye St., N. W.
BARKLEY, John F. ('18; '26), Supvs. Engr., Fuel Economy Serv., Bur. of Mines, 9th & F Sts.
BEAN, Howard S. ('19; '26), Ch., Gas Measuring Instruments Sec., Natl. Bur. of Stands., Connecticut Ave. & Upton St.
BENÉT, Laurence V. ('92), Retired; 2101 Connecticut Ave.
BENJAMIN, Chas. H. ('92), Vice-President, '16-'18; Retired; 1801 Hoban Rd., N. W.
BENSINGER, Mark (J'35), 2737 Devonshire Pl.
BETHON, Henry E. (J'24), Assoc. Mar. Engr., Bur. of Engrg., Navy Dept., 17th St. & Constitution Ave.
BINSSE, Henry B. ('82), Retired; 1308—19th St., N. W.
BLEE, Harry H. ('13; '19), Cons. Engr., 4000 Cathedral Ave.
BLOOM, Jack R. (J'31), Treasury Dept.; *for mail,* 1332 Massachusetts Ave., N. W.
BLOSE, Jas. F. (J'35), 1912 R St., N. W.
BOLTWOOD, Harvey ('21; '30), Asst. Dir., Bur. of Serv., Interstate Commerce Comm.
BOURKE, F. E. (J'36), Jr. Engr., Hercules Powder Co., Inc.; *for mail,* 1403 Van Buren St., Wilmington, Del.; *home address,* 1789 Lanier Pl., Washington, D. C.
BRACE, Norman G. ('24; '35), M. E., Bur. of Engrg., Navy Dept., Navy Bldg., Washington, D. C.; *for mail,* 719 Richmond Ave., Silver Spring, Md.
BRIGGS, Wm. C., Jr. ('34; '35), Asst. M. E., Div. of Procurement, Treasury Dept.; *for mail,* 1705 Lanier Pl., N. W.
BRUNETT, Adrian L. ('19; '25), Assoc. M. E., Constr. Div., U. S. Veterans Admin., Washington; *for mail,* P. O. Box 16, Rockville, Md.
BUCK, Wm. H. ('25; '31), Apt. 23, 1325—13th St., N. W.
BURDICK, Lewis R. ('36), Assoc. Fuel Engr., Bur. of Mines, 900 F St., N. W., Washington, D. C.; *for mail,* 724 Chesapeake Ave., Silver Spring, Md.
BUYERS, Archie S. ('12; '25), Lieut.-Col., Ord. Dept., Office of Chief of Ord., War Dept.
CADWALLADER, Lewis W. (J'34), Generating Sta. Oper., Potomac Elec. Power Co., 10th & E Sts., N. W.; *for mail,* 4301—38th St., N. W.
CARTY, Roy F. ('30), Pres., M. E., Carty Elec. & Armature Serv., Inc., 1608—14th St., N. W.
CHEYNEY, A. R. ('12), E. E., Post Office Dept.
CLINGERMAN, Robt. L. ('30), Cons. Engr., Wm. Bayley Co., Springfield, Ohio; *for mail,* 3701 Massachusetts Ave., N. W., Washington, D. C.
CONANT, Wm. S. ('95; '04), Cons. Engr., 1402 31st St., N. W.
CONE, H. I. ('10; H'36), Rear Admiral, U. S. N., Retired; *for mail,* 2540 Massachusetts Ave., N. W.
CONRAD, Col. W. L. ('17), 923—15th St., N. W.
COOK, Howard L. (J'32), Soil Conservationist, Soil Conservation Serv., Stand. Oil Bldg., Washington, D. C.; *for mail,* 134 Fairmont Ave., Bethesda, Md.
COX, Edw. L. (J'23), 3404 Rodman St., N. W.
CRUICKSHANKS, Benj. C. ('32), Assoc. Prof. M. E., George Washington Univ.; *for mail,* 5733—4th St., N. W.
DACANAY, Bernabe R. (J'31), 907 L St., N. E.
DEW, Philip H. (J'27), Jr. Engr., Carrier Corp., Tower Bldg., 12th & K Sts., N. W.
DICKINSON, H. C. ('19), Ch., Heat & Power Div., Natl. Bur. of Stands.
DOOLIN, Elmer ('33; '35), Pres., Service Engrg. Co., 501 L St., N. W.
DRYDEN, Hugh L. ('36), Ch., Mechanics & Sound Div., Natl. Bur. of Stands.
DUPONT, Andrew T. ('18; '24; '29), Pat. Lawyer, 311 McGill Bldg.; *for mail,* 2158 Florida Ave., N. W.
EATON, Herbert Nelson ('30), Chief, Hyd. Lab. Sec., Natl. Bur. of Stands., Washington, D. C.; *for mail,* 3 E. Inverness Driveway, Chevy Chase, Md.
ELLENBERGER, Wm. J. (J'34), Power Sales Engr., Potomac Elec. Power Co., 10th & E Sts., N. W.; *for mail,* 1359 Parkwood Pl., N. W.
ELLIS, Miss Dorothy M. (J'29), Statistical Clerk, Div. Crop & Livestock Estimates, Bur. of Agri. Economics, Dept. of Agri.; *for mail,* Apt 105, 2514 Q St., N. W.
ELY, Edwin W. ('22; '35), Ch., Div. Simplified Practice, Natl. Bur. of Stands.; *for mail,* 2426 19th St., N. W.
ENSINGER, Willis B. (J'31), Asst. M. E., Bur. of Ord., Navy Dept.; *for mail,* 3828 Van Ness St.
ERWIN, Henry P. ('24), 723—15th St., N. W.
EUSTON, Edwin ('19), Wardman Park Hotel.
FARR, Wm. S. (J'29), Sales Engrg., Air Reduction Sales Co., 50 Florida Ave.
FEIKER, Fred'k M. (A'12), Exec. Secy., Am. Engrg. Council, 744 Jackson Pl., N. W.
FINNEY, John H. V. ('30), Assoc. M. E. Fire Resistance Sec., Dept. Heat & Power, Natl. Bur. Stands.; *for mail,* 4550 Connecticut Ave.
FORNEY, J. Raymond ('15; '35), Ry. Supply Business, 305 McLachlen Bldg.
FOX, Jas. Fulton ('32; '35), M. E., Design Sec., Bur. of Ord., Navy Dept.; *for mail,* 401—23d St., N. W.
FREEMAN, Lewis D. ('13; '25), Consultant, Sec. of Purchases, Federal Coordinator of Transportation, Washington, D. C.; *for mail,* 604 N. Blvd., Richmond, Va.
FULLMER, Irvin H. ('19; '25; '34), Physicist, Gage Sec., Natl. Bur. of Stands.
GAILLARD, David St. P. ('17; '19; '35), 839—17th St., N. W.
GALLOWAY, Robt. R. ('31), Natl. Parks Serv., Dept. of Interior; *for mail,* 7701 Georgia Ave.
GARDNER, S. Franklin ('21), Mem. Firm, Stand. Engrg. Co., 2129 Eye St., N. W.
GICHNER, Jacob H. ('25; '32; '35), Supt. & Prod. Mgr., Fred S. Gichner Iron Wks., Inc., 1214—24th St., N. W., Washington, D. C.; *for mail,* 5620 Western Ave., Chevy Chase, Md.
GIEGENGACK, A. E. ('34), Public Printer, Govt. Ptg. Office; *for mail,* Wardman Park Hotel.
GILLIS, Harry A. ('88; F'36), Manager, '01-'04; M. E., 930 Barr Bldg.
GILLIS, Irvin V. ('17), c/o H. A. Gillis, 2301 Pennsylvania Ave., N. W.
GOODWIN, Eugene W. ('31), M. E., Design, Treasury Dept., Washington, D. C.; *for mail,* 7024 Hampden Lane, Bethesda, Md.
GORDON, Gerald L. (J'32), Central Office Maint., Chesapeake & Potomac Tel. Co., 1111 N. Capitol St.; *for mail,* Apt. 3, 4809—4th St., N. W.
GRAHAM, Warren W. ('18; '35), Design Engr., 1858 Columbia Rd.
GREEN, Wilson P. (J'32), 1742 P St., N. W.
GURNEY, Dayton A. ('14), Ord. Engr., Ord. Office, War Dept., Washington, D. C.; *for mail,* 8 Holly Rd., Cheverly, Md.
HAAS, Hugo H. ('29), Diesel M. E., War Dept., Corps of Engrs., Munitions Bldg.; *for mail,* 78 Buena Vista Terrace, S. E.
HALLETT, Saml. G. ('23; '25; '31), Sr. M. E., Bldgs. Branch, Natl. Parks Serv., Dept. of Interior, 1707 Navy Bldg.; *for mail,* 808—21st St., N. W.
HAMILTON, Jas. ('98), Pat. Lawyer, Munsey Bldg., 1329 E St., N. W.
HANSON, Alfred E. ('19; '26), Mech. Supt., Charge Engrg. & Maint., Govt. Ptg. Office.
HARRIMAN, N. F. ('04), Fed. Specifications Bd., Federal Warehouse, 9 & D Sts., S. W.
HARRINGTON, Francis D. (J'32), Jr. Engrg. Draftsman, Optical Design Sec., Bur. of Ord., U. S. Naval Gun Factory, Navy Yard; *for mail,* Apt. 2, 724 Irving St., N. E.
HARRISON, J. Houston ('23), M. E. of Valuation, So. Ry. System, Rm. 940, McPherson Sq.
HARRISON, Robert L. ('23), Capitol Power Plant, Office of the Arch. of the Capitol, Washington, D. C.; *for mail,* 19 Keswick St., Garrett Park, Md.
HEALD, Royal H. ('19; '21; '35), Assoc. Physicist, Natl. Bur. of Stands., Connecticut Ave. & Van Ness St.; *for mail,* 6201 Utah Ave., N. W.
HEINE, Gregor H. ('18; '24), Cons. Engr., Weller Corp., 604 Mills Bldg.; *for mail,* 1327 Newton St., N. E.
HERSCHEL, Winslow H. ('32), Matls. Engr., Natl. Bur. of Stands., Washington, D. C.; *for mail,* 6305 Florida St., Chevy Chase, Md.
HOLCOMBE, Amasa M. (A'16), Sr. Partner, Emery, Booth, Holcombe & Miller, 438 Munsey Bldg., Washington, D. C.; *for mail,* 8 Rosemary St., Chevy Chase, Md.
HOLTZCLAW, Henry J. ('33), Engr., Charge Design, Bur. of Engraving & Ptg.
HOOD, Ozni P. ('04), Retired; 1831 Irving St., N. W.
JAKOBSSON, G. Herman ('07), Pat. Atty., Cons. Engr., Glassock, Downing & Seebold, 743 National Press Bldg.
JANSSON, Martin E. ('31; '35), 602 Roxboro Pl., N. W.
JOHNSON, Arthur E. ('90; '92), Life Member; Mech. Designer, Ord. Office, War Dept.; *for mail,* 2155 New York Ave., N. W.
JOHNSON, Arthur F. ('24), Prof. M. E., Geo. Washington Univ., Washington, D. C.; *for mail,* 1021 Oakcrest Rd., Arlington, Va.
JOHNSON, Col. John O. ('28), Cons. Engr., 506 Mills Bldg., Pennsylvania Ave. & 17th St.
KAPRELIAN, Edw. (J'34), Jr. Pat. Examiner, U. S. Pat. Office, 14th & E Sts.; *for mail,* 646 Franklin St., N. E.
KARSUNKY, Wm. Karl ('22; '31), Cons. Engr., 1526 K St., Washington, D. C.; *for mail,* "Three Oaks," Newport Mill Rd., Kensington, Md.
KEMP, Harold A. ('20; '31), Supt., Charge Design & Constr., Sewage Treatment Plant for Dist. of Columbia, District Bldg., Washington, D. C.; *for mail,* 2912 N. Glebe Rd., Cherrydale, Va.
KERR, C. Phillips ('16; '28), Ch. Review Sec., Bd. of Review, Pub. Wks. Admin., Interior Bldg., Washington, D. C.; *for mail,* 214 Wilson Lane, Bethesda, Md.

KOONTZ, Lamont B. (J'33), Jr. Pat. Examiner, U. S. Pat. Office, 14th & E Sts.; *for mail*, 1401 Tuckerman St.
KROGMANN, Francis X. (J'30), Constr. Accountant, Washington Gas Light Co., 411—10th St., N. W.; *for mail*, 3301—20th St., N. E.
KUGEL, H. K. ('13; '22), Smoke Control Engr., Govt. of Dist. of Columbia, Rm. 306, District Bldg.
LANIGAN, Thos. M., Jr. ('22; '27; '35), 1368 Harvard St., N. W.
LAWRENCE, Walter B. ('27; '29), Assoc. M. E., Pub. Bldgs. Branch, Div. of Procurement, Treasury Dept.; *for mail*, 711 Mt. Vernon Pl., N. W.
LEGGETT, Lieut. W. D., Jr. (J'28), 2821—29th St., N. W.
LUNDH, S. H. ('29; '35), M. E., Bur. of Engrg., Navy Dept.; *for mail*, 1839 Wyoming Ave.
MAGDEBURGER, E. C. ('17; '20), Aide on Diesel Engs., Bur. of Engrg., Navy Dept.; *for mail*, 4419 New Hampshire Ave.
MARK-WARDLAW, Alex. L. P. ('35; '35), Commdr. (E) R. N., Asst. Naval Attaché, British Embassy, 3100 Massachusetts Ave.
MARSHALL, Gen. R. C., Jr. ('19), Cons. Engr., Shoreham Bldg., 15th & H Sts., N. W.; *for mail*, 1211—16th St., N. W.
MARZOLF, Jos. M. ('19), Sr. M. E., Bur. of Yds. & Docks, Navy Dept.; *for mail*, 1703 Taylor St., N. W.
MASON, Martin A. (J'32), M. E., Instrument Testing, Natl. Bur. of Stands.; *for mail*, 2902 Porter St., N. W.
MATHEWS, H. Hume (J'35), Jr. Pat. Examiner, U. S. Pat. Office, Washington, D. C.; *for mail*, 46 Elm Ave., Takoma Park, Md.
MAYS, Jas. S. (J'36), 1759 Lanier Pl., N. W.
McBURNEY, John W. ('26), Rep. of Am. Standards Assn., Natl. Bur. of Stands., Washington; *for mail*, 414 Taylor St., Chevy Chase, Md.
McCLELLAN, Wm. ('05), Pres., Potomac Elec. Power Co., 10th & E Sts., N. W.
McCRARY, John A. ('12), M. E., Charge Wind Tunnels, Navy Yard.
MELICK, Neal A. ('20), Supvg. Engr., Pub. Bldgs. Branch, Div. of Procurement, Treasury Dept., 712 Federal Warehouse; *for mail*, 2101 New Hampshire Ave., N. W.
MERRILL, O. C. ('24), Cosmos Club.
METZ, Walter R. ('02; '11), Ch. Engr., Charge Design, U. S. Veterans Admin.; *for mail*, 1727 Taylor St., N. W.
MILLER, Carl E. (J'36), Test Engr., Potomac Elec. Power Co., Washington, D. C.; *for mail*, 704—24th St., S. Aurora Hills, Arlington, Va.
MITCHELL, J. F. (J'35), 1631 Euclid St., N. W.
MONTAGUE, Edwin Newell ('29; '35), Sr. Specialist & Asst. Dir., Employment Serv., Dept. of Labor.
MORTON, Geo. L. ('90), Retired; Apt. 108, The Ontario.
MULLEN, T. J., Jr. (J'36), Sales Engr., B. F. Sturtevant Co., 708 Mills Bldg.
MULLER, Victor (J'32), Jr. Pat. Examiner, U. S. Pat. Office; *for mail*, 214 Massachusetts Ave., N. E.
NEWMAN, Simon M. (J'29), Asst. Pat. Examiner, Div. 20, U. S. Pat. Office, Washington, D. C.; *for mail*, 30 Westmoreland Ave., Takoma Park, Md.
NORDLINGER, S. G. (J'33), 1st Lieut., Res. Engr., U. S. A. Hdqtrs., 12th Sub-Dist., Beltsville, Md.; *for mail*, 1933—19th St., N. W., Washington, D. C.
NOYES, Mason S. ('33; '35), Design Div., Bur. of Engrg., Navy Dept., Room 2241, Navy Bldg.
OBERLIN, E. G. ('16), Capt., U. S. N., Retired; *for mail*, Route 4, Anacostia.
OSBORN, Earl P. ('31), Assoc. Aero. Engr., Structures, Bur. of Aeronautics, Navy Dept., Navy Bldg., Washington, D. C.; *for mail*, 2625—18th St., N., Arlington, Va.
PETERSON, V. H. ('25; '32; '35), Dist. Mgr., Elliott Co., 918 Washington Loan & Trust Bldg.; *for mail*, 6327 Western Ave., N. W.
PHELAN, Col. John J. ('35), Utility Officer, M. E. & C. E., U. S. Veterans Admin., 2560 Wisconsin Ave.; *for mail*, 1359 Park Rd., N. W.
PHILLIPS, John Chester (J'32), Jr. Engr., Design, Bur. of Ord., Navy Dept.; *for mail*, 2309—36th St., S. E.
POSSEL, Adrian M. ('24; '31), Rm. 1821, South Bldg., Dept. of Agric.
PRICE, Henry M. ('12), 923 Colorado Bldg.
RANDALL, John A. ('11; '12; '13), Dir. Ed. Aids, Natl. Youth Admin., 1340 G St., N. W.
REESE, L. V. ('24), 3133 Connecticut Ave.
REZNEK, Ben (J'35), 201—15th St., N. E.
RHOADS, Robt. L. ('19; '25), Mech. Engrg. Dept., Catholic Univ. of Am.
RICHARDS, Edwin H. (J'32), 1640 Irving St., N.W.
RIEGGER, Wm. G. ('26; '30; '35), M. E., Plumbing & Heating, Inspc. Div., Low Cost Housing, Pub. Wks. Admin.; *for mail*, 6602—1st St., N. W.
RILEY, Edw. C. (J'32), Asst. Pub. Health Engr., Indus. Hygiene Labs. (Office of Indus. Hygiene & Sanitation), U. S. Pub. Health Serv.
RIPLEY, Kenneth C. (J'29), Asst. Physicist, Naval Research Lab., Anacostia; *for mail*, 116 Upsal St., S. E., Washington.
ROBERT, L. W., Jr. ('14; '23), 298 Treasury Dept.
ROGERS, John H. (J'36), 910 Decatur St., N. W.
ROSE, Leonard J. ('24; '35), Consultant, M. E., Munitions Bldg., War Dept.; *for mail*, 1841 Park Rd., N. W.
ROSS, Sir Chas. ('10), Cons. Engr., 1619 Massachusetts Ave., N. W.
RUBINOWITZ, Leo (J'31), Asst. Physicist, U. S. Exper. Model Basin, Navy Yard; *for mail*, 518—4th St., N. E.
RUDGERS, Anthony J. (J'29), Cataloger, Div. of Procurement, Treas. Dept., Washington, D. C.; *for mail*, 219 N. Fillmore St., Arlington, Va.
SANFORD, L. R. ('21), Cons. Engr., 803 Mills Bldg.
SCHMELTZER, J. E. ('15; '24), Engr., Charge Design, U. S. Maritime Comm., Dept. of Commerce Bldg.; *for mail*, 4420 Brandywine St.
SCHMIDT, John F. (J'35), Pat. Searcher & Student Atty., Gen. Elec. Co., Munsey Bldg.
SCHNEIDER, Carl ('19; '25), Constr. Engr., Wks. Progress Admin., 1734 New York Ave., N. W.; *for mail*, 7300 Blair Rd.
SCHOENBORN, Wm. E. ('91; '13), Solicitor of Patents, Earle Bldg., 13th & E Sts., N. W.
SCHREIBER, Herman V. ('17), Safety Engr., Capital Transit Co., 36th & M Sts., N. W.; *for mail*, 3907 Huntington St., N. W.
SCHWARTZ, Andrew J. ('19), Sr. Engr., Design Sec., U. S. Naval Gun Factory; *for mail*, 32 Rhode Island Ave., N. W.
SEARLE, Russell M. ('18; '21; '35), Cons. Staff, Govt. Resettlement Admin.; *for mail*, 3700 Massachusetts Ave., N. W.
SEIBERT, Chas. Jay ('24), 6310—8th St., N. W.
SIHLER, John H. (J'31), Assoc. Engr., Ord. Design, Bur. of Ord., Navy Dept.; *for mail*, 918—18th St., N.W.
SIMPSON, Geo. R. ('89; '97), Pat. Examiner, Ry. & Rolling Stock Div., U. S. Pat. Office, 304 U. S. Pat. Office Bldg.; *for mail*, 5409—16th St., N. W.
SMOOT, Lewis E. ('30), Life Member; Chmn. Bd., Smoot Sand & Gravel Corp., 3020 K St., N. W.
SNELLING, Henry Hornor ('18; '19), Sr. Mem., Snelling & Hendricks, 908 G St., N. W., Washington, D. C.; *for mail*, 6708—45th St., Chevy Chase, Md.
STEWART, Wm. B. (J'36), Matls. Engr., Sample Rm., Div. of Procurement, Treasury Dept., 7th & D Sts., S. W.; *for mail*, 1442 Clifton St., N. W.
STORM, Robt. E. ('32; '35), Welding Engr., Dept. of Interior, Veterans Admin. Bldg.; *for mail*, 1681 Columbia Rd.
SULLIVAN, W. E. ('28; '32), Lieut. Comdr., Bur. of Engrg., Navy Dept.
SWANSON, Carl H. (J'36), Student Sales Engr., Ingersoll-Rand Co., Phillipsburg, N. J.; *home address*, 3715 Fulton St., N. W., Washington, D. C.
SWART, A. W. (J'35), Jr. Engrg. Draftsman, Ord., Navy Yard, 8th & M Sts., S. E., Washington, D. C.; *for mail*, 1416 N. Barton St., Arlington, Va.
TATE, Thos. R. ('26), Ch., Power Resources & Requirements Div., Fed. Power Comm., 930 H St., N. W.; *for mail*, 6018 Utah Ave., N. W.
TAYLOR, Arthur (J'30), Engr., Potomac Elec. Power Co.; *for mail*, 1931 S St., N. W.
TAYLOR, Arthur Yates (J'30), Jr. Engr., Potomac Elec. Power Co., 10th & E Sts., N. W.; *for mail*, 2229 Bancroft Pl.
TAYLOR, Walter C. ('36), Sr. Tech. Adviser, Textile Labor Relations Bd., New Labor Bldg.; *for mail*, 3000 Connecticut Ave., N. W.
THIELSCHER, Herman G. ('23; '27), M. E., Potomac Elec. Power Co., 10th & E Sts., N. W.
THOMAS, Percy H. ('16), Chief, Power Requirements Div., Fed. Power Comm.
THOMPSON, John R. ('15), Principal M. E., Rm. 6133, Bur. of Valuation, Interstate Commerce Comm.
THUNEY, F. M. (J'32), Engr., Charge Application, Wm. E. Kingswell, Inc., 3707 Georgia Ave., N. W.
TRACK, Frank A. ('18; '22), Assoc. Naval Arch., Navy Dept., Rm. 2149, Navy Bldg.
TRIPP, Louis H. ('21), Dir. of Constr., U. S. Veterans Admin.; *for mail*, 3721 Fulton St., N. W.
TURNER, Otis L. (J'33), Sales Engr., Washington Refrigeration Co., 1731—14th St., N. W., Washington, D. C.; *for mail*, E. Falls Church, Va.
VASTA, John (J'30), U. S. Exper. Model Basin, Navy Yard.
VON PAGENHARDT, Maximilian ('32), Pres., M. H. Pagenhardt & Co., 2415 Foxhall Rd., N. W.
WAGNER, Jas. J. ('22), Engr., Power Div., Pub. Wks. Admin., Interior Bldg.; *for mail*, Martinique Hotel, 16th & M Sts.
WALLACE, John H. G. (J'33), Pat. Examiner, U. S. Pat. Office; *for mail*, 3945 Connecticut Ave.
WALSH, John H. (J'29), Asst. M. E., Div. of Procurement, Treasury Dept.; *for mail*, 1821 Belmont Rd., N. W.
WESCHLER, Geo. A. ('16), Cons. Engr., 732—17th St., N. W.
WESCHLER, Maurice E. ('21; '31), Assoc. Prof. M. E., Catholic Univ. of Am.; also M. E. with Geo. A. Weschler, 732—17th St., N. W.; *for mail*, 1335 Newton St., N. E.
WHITTEMORE, Herbert L. ('03; '10; F'36), Manager, '30-'33, Ch., Engrg. Mechanics Sec., Natl. Bur. of Stands., Connecticut Ave. & Van Ness St., N. W.; *for mail*, 3906 McKinley St., N. W.
WILBERDING, Marion X. ('28), Pres., Weller Corp., 604 Mills Bldg.
WILLIS, Philip A. ('29; '35), M. E., Examiner, U. S. Civil Serv. Comm., 7th & F Sts.; *for mail*, 211 Delaware Ave., S. W.
WILLISTON, Arthur L. ('96; '99), Am. Council on Education, 26 Jackson Pl., Washington, D. C.; *for mail*, 986 High St., Dedham, Mass.
WILSON, Lester G. ('03; '07; '13), Cons. Engr., Investment Bldg., Washington, D. C.; *for mail*, 20 Magnolia Pkwy., Chevy Chase, Md.
WOODRUFF, DeForest Douglas (J'31), Serv. Supvr., Hudson Air Conditioning Corp., 1517 Connecticut Ave.; *for mail*, 4409—18th St., N. W.
YOUNG, Selah P. ('22; '35), Asst. M. E., Design Sec., Bur. Yards & Docks, Navy Dept.; *for mail*, 1818 Ingleside Terrace, N. W.
ZIMMERLUND, Leonard E. (J'33), 1801 Massachusetts Ave.

FLORIDA

CLEARWATER, Florida Section

JONES, Edw. H. ('89).
RIDDLE, Howard S. ('05), Dist. Administrator, Fla. Emergency Relief Admin., Ft. Harrison Hotel; *for mail*, Clearwater.

CLEWISTON, Florida Section

SCHARNBERG, Herman J. B. ('20), Gen. Supt., Charge Maint. & Prod., U. S. Sugar Corp.; *for mail*, 32 Del Monte Ave.

CORAL GABLES, Florida Section

CLOUSE, John Henry ('30; A'31), Asst. Prof. Physics, Univ. of Miami.
DEE, Wm. V. (A'18), 825 Sorolla Ave.
JENSEN, J. O. ('33), 534 Anastasia Ave.
TIGERT, John J., Jr. (J'35), Apprentice Engr., Pan Am. Airways System, New York, N. Y.; *for mail*, 118 Menores Ave., Coral Gables, Fla.

DANIA, Florida Section

COUCHMAN, Verne C. ('24; '35), Boiler Rm. Engr., Fla. Power & Light Co.; *for mail*, Dania.
WARREN, Jas. P. ('22; '24), Plant Supt., Charge Opera. & Maint., Fla. Power & Light Co., Box 275.

DAVENPORT, Florida Section

DEWSON, Edw. H. ('89; '98), Holly Hill Fruit Products, Inc.

DeLAND, Florida Section

LOWRY, Curtis M. ('31; '35), 519 San Souci Place.

EUSTIS, Florida Section

PINKERTON, David W. ('30), Box 99.

FORT LAUDERDALE, Florida Section

BEENSEN, Chas. ('22; '35), Betterment Engr., Fla. Power & Light Co., Dania; *for mail*, P. O. Box 2393, Ft. Lauderdale.
GRAVES, Geo. R. ('28; '35), Oper. Engr., Fla. Power & Light Co., Dania; *for mail*, P. O. Box 2733, Ft. Lauderdale.

GAINESVILLE, Florida Section

EBAUGH, Newton C. ('32; '35; '35), Head Prof., M. E. Dept., Univ. of Fla.
HARTMAN, Merton T., Jr. (J'34), P. O. Box 227.
JANES, C. Howell (J'31), Instr. M. E., Univ. of Fla., E. 303.
STRONG, Albert J. ('27), Prof. Drawing, Univ. of Fla.; *for mail*, 324 W. Court St.
THOMPSON, Robt. Alden (J'33), Instr. M. E., Univ. of Fla.; *for mail*, 1225 W. Arlington St.
VAN LEER, Blake R. ('20; '25), Dean, College of Engrg., Univ. of Fla.
YEATON, Philip O. ('20; '25), Head of Dept. & Prof. Indus. Engrg., Univ. of Fla., E. 207.

HOMOSASSA SPRINGS, Florida Section

MELCHER, Chas. W. ('90), Retired.

JACKSONVILLE, Florida Section

DREW, Walter E. (J'36), Effic. Engr., Municipal Power Plant; *for mail*, P. O. Box 3344.
IMESON, Chas. V. ('17; '25), Engr.-Examiner, Pub. Wks. Admin.; *for mail*, 718 Gilmore St.
KINGSBURY, R. W. ('35), Assoc. Supt., U. S. Engr. Dept., P. O. Bldg.
SMITH, Geo. Hoffman (J'30), Shell Petroleum Corp., Lynch Bldg.

LAKELAND, Florida Section

KENNEDY, Sidney G. ('18; '21), Gen. Foreman, Atlantic Coast Line R. R. Co.; *for mail*, 402 S. Kentucky Ave.
YOHE, C. H. (J'28), Tool Designer & Draftsman, Juice Extracting Mchy. Co., 415 S. Ingram; *for mail*, 1011 Brunell Ave.

LAKE MONROE, Florida Section

STANSFIELD, Wm. Ashton (J'31), Sta. Clerk, Fla. Power & Light Co.

LIVE OAK, Florida Section

McKNIGHT, E. W. (J'36).

MELBOURNE, Florida Section

RITTER, Paul Alex. ('25), 16 Helen St.

MIAMI, Florida Section

BEECHER, Clarence Y., Jr. (J'33), Rep., Miami Natl. Houses, 39th St. & Park Ave., New York, N. Y.; *for mail*, 7815 N. W. 7th Ave., Miami, Fla.
BROWN, William Alfred (J'27), Constr. Engr., P. J. Davis Constr. Co.; *for mail*, 410 N. E. 28th St.
CAMPBELL, Geo. W. (J'36), Jr. Engr., Gen. Air Conditioning Co., Inc., 909 Olympia Bldg.; *for mail*, 253 N. W. 34th St.
DOUGHERTY, Chas. J. ('27), Cons. M. & E. Engr., 3671 Matheson Ave., Coconut Grove.
DuBOSQUE, F. L. ('92), 4376 N. Bay Rd., Miami Beach.
GEBHARDT, Geo. F. ('04), Prof. Emeritus of M. E., Armour Inst. of Tech., Chicago, Ill.; *for mail*, 469 N. E. 69th St., Miami, Fla.
HOLLEMAN, Howard I. ('19), P. O. Box 5.
JOHNSON, Werner ('03), Retired; 465 N. W. 4th St.
LAMBERT, Carl F. ('20), Utility Engr. & Cons., 805 Biscayne Bldg.
LANDVOIGT, Thos. E. ('17), Liberty Sq. Housing Project, Pub. Wks. Admin.; *for mail*, 2010 N. Bayshore Dr.
LESLIE, Bernard S. ('15; '25), Pres., John D. Clark, Inc., 1405 Security Bldg.
McKINNEY, August G. (J'36), Jr. Engr., Pan Am. Airways System, Miami; *for mail*, 2401 S. W. 28th, Coconut Grove.
MERSHON, Ralph D. ('00), Cons. Engr., 2000 Tiger Tail Ave.
POOL, Ralph Y. ('21), Fla. Power & Light Co.
SARGENT, Wm. D. ('96), Dir., Am. Steel Fdys. Co.; Am. Brake Shoe & Fdy. Co.; *for mail*, 3756 Pine Tree Dr., Miami Beach.
STOREY, Norman C. ('18; '35), Pres., Gen. Mgr., Storey Mch. Shop & Mfg. Co., Inc., 825 N. W. 72nd St., P. O. Box 1363, Little River Sta.
STUHRMAN, Ahlert Percy (J'34), 9454 N. E. 4th Ave.
WHITE, J. H. (J'19), Gen. Supt., Fla. Power & Light Co.
WILEY, R. B., Jr. (J'35), M. E., Charge Design, Installation, Belcher Industries, Inc., 1221-1223 Biscayne Blvd.

ORLANDO, Florida Section

FOX, Wm. ('00), 126 N. Rosalind Ave.

PAHOKEE, Florida Section

WHITCOMB, Chas. F., Jr. (J'34), Fla. Power & Light Co.

PALATKA, Florida Section

STARKEY, David W. ('18), 423 Emmett St.

PALM BEACH, Florida Section

BROMBACHER, Max H. C. ('21), Supt. of Properties, Fla. East Coast Hotel Co.

PANAMA CITY, Florida Section

KILLINGER, Clarence E. (J'34), Opera. Engr., So. Kraft Corp.; *for mail*, Panama City.

PENSACOLA, Florida Section

ATKINSON, Calder (J'36), Aviation Cadet, Class 94C, Cadet Barracks, Naval Air Sta.
BARNABY, Ralph S. ('15; '22; '35), Lieut.-Comdr., U. S. N., Naval Air Sta.
HILANDS, W. H. (J'36), Aviation Cadet, Naval Air Sta.
HOWE, Fred J. (J'35), Draftsman, State Rd. Dept. of Fla., 306 N. Adams St., Tallahassee; *for mail*, P. O. Box 883, Pensacola.
LONG, Richard H. (J'35), Cadet, Naval Air Sta., Pensacola, Fla.; *for mail*, 202-07 104th Ave., Hollis, L. I., N. Y.
RUSSELL, Edw. W. (J'34), Engrg. Aide, Resettlement Admin., Milton; *for mail*, 606 W. Garden St., Pensacola.
SWEENEY, Jas. L. (J'34), 206 E. Liberty St.
SWEET, Arthur Burr (J'36), Aviation Cadet, Cadet Barracks, Naval Air Sta.
TROTH, Hubert C. (J'36), Aviation Cadet, Naval Air Sta.
VENSEL, Jos. Richard (J'33), Aviation Cadet, Naval Air Sta., Bldg. 233.

PIERCE, Florida Section

LOOMIS, Burdett, Jr. ('04), Mgr. Phosphate Rock Mines, Am. Agri. Chem. Co.

PLANT CITY, Florida Section

PEYINGHAUS, Robt. ('19; '35), Elec. Supt., Coronet Phosphate Co.; Elec. Inspr. of Plant City, Teacher, Vocational Math. & Elec., State of Fla.; *for mail*, Box 403, Plant City.

ST. AUGUSTINE, Florida Section

HALLER, R. V. (J'35), 98 Bridge St.
RODENBAUGH, H. N. ('22), V. P., Fla. East Coast Ry. Co.

ST. PETERSBURG, Florida Section

WELLS, Eliot C. (J'18), Oper. Supt., Fla. Power Corp.; *for mail*, 4535—9th Ave., N.

SANFORD, Florida Section

CORNELL, Robt. L. ('27), Pres., Fla. Precooling Co.

SARASOTA, Florida Section

TAYLOR, Howard Smith ('23), 238 Grove Ave.

TALLAHASSEE, Florida Section

KNOLL, Herman (J'36), Draftsman, Design & Estimating, Resettlement Admin.; *for mail*, 525 W. Park Ave.

TAMPA, Florida Section

BOLTON, Chas. H., Jr. (J'34), Air Conditioning Engr., Byars-Forgy Refrigeration Co., Inc., 102 E. Lafayette.
ERICKSON, Ole P. ('28), M. E., Asst. Mgr., Shell Producers Co., 115 S. Water St.; *for mail*, 819 Grove Park Ave., Beach Park.
HALE, Arthur B. ('22; '27), Mech. & Refrig. Engr., P. O. Box 1425.
KREHER, Ernest ('15), Pres., Gen. Mgr., Tampa Shipbldg. & Engrg. Co., Box 1838.

WEST PALM BEACH, Florida Section

LIPPS, Henry, Jr. ('88; '91), Retired; 237 Monroe Dr.
WHITING, Chas. W. ('85; '95), 200 Greenwood Dr.
WILSON, Chas. R. (J'32), 276 Cordova Rd.

WINTER PARK, Florida Section

HUNTER, John ('09), Manager, 13-'16; Vice-President, '17-'19; Cons. Engr., 2346 Fairbanks Ave.

GEORGIA

ATLANTA, Atlanta Section

ALDINGER, H. K. ('24), M. E., Fulton Bag & Cotton Mills; *for mail*, 1240 Mansfield Ave.
ALLISON, Carl O. ('28; '30; '35), Constr. Engr., Div. of Procurement, Pub. Bldgs. Branch, Treas. Dept., Washington, D. C.; *for mail*, Old Post Office Bldg., Atlanta, Ga.
ATKINSON, Ernest H. (J'35), 971 Oakdale Rd., N. E.
BELL, Thos. E. ('26; '33; '35), Dist. Mgr., Republic Flow Meters Co., 412 Red Rock Bldg.
BENJAMIN, Ray N. ('25), M. E., Ga. Power Co., Electric Bldg.; *for mail*, 74—17th St.
BRADLEY, L. F. (J'32), 225 Crumley St., S. W.
BRAUNGART, Geo. Jr. ('22), V. P., Gen. Mgr., Bradford Ice Co., 1516 Jonesboro Rd.
BRENNER, Wm. H. ('97), 3467 Peachtree Rd.
BROOKS, Eugene A. ('18; '25), Pres., Boiler Equip. Serv. Co., 686 Greenwood Ave., N. E.
CAMP, E. V. (17; '35), Pres., E. V. Camp & Associates, Inc., 215 Moreland Ave., N. E., P. O. Box 62, Sta. E.
COOLIDGE, C. E. ('17), Prof. Mch. Design, Ga. Sch. of Tech.; *for mail*, 512 Page Ave.
COON, J. S. ('80), Prof. Emeritus M. E., Ga. Sch. of Tech.
DODD, John A. ('24; '30), Owner, John A. Dodd Co., 101 Marietta St., N. W.
DOUGHTIE, Chas. E., Jr. ('27; '35), Mgr., M. E. Dept., Robert & Co., Inc., 704 Bona Allen Bldg.; *for mail*, Apt. 6, 5 Collier Rd.
DRUM, Leo. J., Jr. (J'35), Student Engr., Sales Engrg., Estimating, York Ice Mchy. Corp., Houston St., Atlanta, Ga.; *for mail*, 120 Sayre St., Montgomery, Ala.
DUNKIN, Wm. V. ('09), Div. Indus. Mgmt., Ga. Sch. of Tech.
ELSAS, Norman E. ('21; '33), V. P., Fulton Bag & Cotton Mills; *for mail*, Box 1726.
ELSAS, Wm. R. (J'30), Asst. to Pres., Fulton Bag & Cotton Mills.
EMERSON, C. L. ('27), V. P., Ch. Engr., Robert & Co., Inc., 706 Bona Allen Bldg.
FAULKNER, Carlos L. (J'36), Oper., (Oil Hydrogenating), Swift & Co., 566 Wells St., S. W.; *for mail*, 59 Inman Circle, N. E.
FIELD, Ernest G. ('19; 24; 30), Indus. Engr., Wm. H. James & Associates, 901-4 Hurt Bldg.; *for mail*, 670 Park Dr., N. E.
HAGOOD, Chas. B., Jr. (J'34), Apt. B-6, 641 N. Highland Ave.
HALE, Stephen C. ('22; '35), Ch. Engr., Fulton Bag & Cotton Mills; *for mail*, 1403 Emory Rd., N. E.
HALL, Roland B., Jr. ('15), Mem. Firm, Burford, Hall & Smith, 140 Edgewood Ave., N. E.; *for mail*, 705 Myrtle St., N. E.
HARPER, E. A. ('34; '35), Ch. Lub. Engr., Texas Co., Mortgage Guaranty Bldg.
HERSAM, Conrad O. ('26), Mfrs., Cons. Engrs., 1310 Rhodes-Haverty Bldg.
HOLLAND, A. Dinsmore ('34; '35), Asst. Prof. M. E., Ga. Sch. of Tech.; *for mail*, 866 Greenwood Ave., N. E.
HOLLINGSWORTH, Louis C. (J'27), Indus. Lub. Engr., Sinclair Refining Co., W. Peachtree St.; *for mail*, 817 Clement Dr., N. E.
HOWELL, Roger S. ('21; '35), Prof. M. E., Dir. Evening Sch. of Applied Sci., Ga. Sch. of Tech.
HUDSON, H. Reynolds (J'34), Undergraduate Student Award, '34; 782 Techwood Dr.
HUTCHINSON, Arthur H. ('99), 1072 W. Peachtree St., N. W.
KAHN, Jas. M. (30; '35), Sales Engr., Internatl. Filter Co., 42 W. 25th St.
KEISER, A. Chas., Jr. (J'32), Indus. Salesman, Texas Co.; *for mail*, 1091 Briarcliff Pl., N. E.
KING, Roy Stevenson ('04; '10), Head, Mech. Engrg. Dept., Ga. Sch. of Tech.; *for mail*, 1293 Oxford Rd., N. E.
KIRBY, W. C. ('29), Contrg. Engr., Grinnell Co., Inc., Atlanta; *for mail*, 306 Ponce de Leon Pl., Decatur.
KLEIN, Edw. W. ('18; '24), S. E. Dist. Mgr., Warren Webster & Co., 152 Nassau St., N. W.
KRAMER, Chester W. (J'27), Sales Engr., Worthington Pump & Mchy. Corp., 133 Carnegie Way.
KUEMPEL, Leon L. (J'29), Mgr., Modutrol Div., Minneapolis-Honeywell Regulator Co., 101 Marietta St.
LEGGETT, I. W. (J'30), Sales Engr., Worthington Pump & Mchy. Corp., 1013 Mortgage Guarantee Bldg.
MANKIN, Guy M. ('30), Sales Engr., 407 Connally Bldg.
MARTIN, Rene J., Jr. (J'35), 1417 Briarcliff Rd., N. E.
MASON, Howard W. ('25), Prof. & Supt. Bldgs. & Grounds, Ga. Sch. of Tech.
MATSON, Ray M. ('29), Assoc. Prof. M. E., Ga. Sch. of Tech.
McWHORTER, Marshall J. (23; '25; '35), 39 Fairhaven Circle.
MERL, Milton F. ('28; '34; '36), Assoc. Editor, Southern Power Journal, W. R. C. Smith Publ. Co., 1020 Grant Bldg.
MILLER, Nils ('36), Dist. Mgr., SKF Industries, Inc., 598 Peachtree St., N. E.
MOODIE, T. Edward ('27; '33; '35), Asst. Prof., Daniel Guggenheim Sch. of Aero., Ga. Sch. of Tech.
MOORE, Wesley R. ('36), Branch Mgr., Minneapolis-Honeywell Regulator Co., 101 Marietta St.
NEEL, Robt. W. ('18; '35), Dist. Sales Mgr., Consltd. Ashcroft-Hancock Co., Inc., 16 W. Andrews Dr.
NEELY, Frank H. ('08; '14), Secy. & Gen. Mgr., Rich's, Inc., Broad & Alabama Sts.
NEWCOMB, Robt. Scott ('09; '25), Partner, Newcomb & Boyd, 708 Walton Bldg.
O'BRIEN, Eugene W. ('21; '27; '31), Manager, '31-'34; Vice-President, '34-'36; Managing Dir., Editor, Southern Power Journal, W. R. C. Smith Publ. Co., 1020 Grant Bldg.
PARKER, John W., Jr. (J'32), Sales Engr., Leo S. Bosarge, 315 Spring St., N. W.; *for mail*, Apt. 1, 936 Juniper St.
RITTELMEYER, John M. ('23; '35), Mgr., Rittelmeyer & Co., 416 Hurt Bldg.
ROBERTSON, Gay A. ('27), Ch. Engr., Atlantic Ice & Coal Co.
SCARBROUGH, G. F. (J'36), 120 North Ave., N. W.
SCOTT, Earl F. ('04; '06; F'36), Manager, '19-'22; Vice-President, '22-'24; Pres. & Mgr., Earl F. Scott & Co., P. O. Box 126, Sta. C.
SHEAROUSE, Jas. D. (J'35), Engr., Charge Design & Prod., So. Iron & Equip. Co., Hemphill Ave. & Southern R. R.
SHUFF, Evans L. ('21; '27), Sales Engr., Power & Mech. Equip., 724 First National Bank Bldg.

SMITH, Talbert E. (J'24), Sales Engr., Burford, Hall & Smith, 140 Edgewood Ave.
TROTTER, Richard A. ('24; '32), Assoc. Prof. M. E., Ga. Sch. of Tech.
WARD, S. E. ('21), Dist. Serv. Mgr., Westinghouse Elec. & Mfg. Co., 426 Marietta St.
WEBER, Homer S. ('24; '31; '35), Assoc. Prof. of Drawing, Ga. Sch. of Tech.
WHITFIELD, Randolph (J'34), Asst. to Automotive Supvr., Ga. Power Co.
WILLIAMS, Jas. Bayard (J'34), Apt. 102, 139 North Ave., N. W.

AUGUSTA, Savannah Section

DOUGLAS, Freeman S. ('22; '26), Wks. Mgr., Babcock & Wilcox Co., Box 923.
HAYES, Paul R. (J'34), Fuel Engr., Blue Diamond Coal Co., Transportation Bldg., Cincinnati, Ohio; *for mail,* P. O. Box 591, Augusta, Ga.

AVONDALE ESTATES, Atlanta Section

PRATT, Ford E. (J'33), 15 Kensington Rd.

CHICKAMAUGA, Chattanooga Section

ZILEN, Victor W. ('13; '24), Route 1, Box 50.

COLLINS, Savannah Section

MOEHRL, Kenneth E. ('26; '32; '35), R. F. D. 2.

DECATUR, Atlanta Section

LAWRENCE, Earl W. ('35; '35), Sales Engr., Norma-Hoffman Bearings Corp., Stamford, Conn.; *for mail,* 632 E. Lake Dr., Decatur, Ga.
McEVER, Wm. L. ('26; '31), 923 Ponce de Leon Ave.

FITZGERALD

MOYER, John O. (J'36), 327 S. Lee St.

LINDALE, Atlanta Section

TURLEY, Comer ('33), Mech. Supt., Pepperell Mfg. Co.; *for mail,* Lindale.

MACON, Atlanta Section

HASKELL, Geo. O. (J'99), Route 4.

MARIETTA, Atlanta Section

GLOVER, Jas. B. (J'28), Engr., Secy., Glover Mch. Wks., P. O. Box 85.

MILLEDGEVILLE, Atlanta Section

MOSHKOFF, S. V. ('28), Charge Properties, Furman Shoals Dev., Ga. Power Co.

NEWNAN, Atlanta Section

TRAPNELL, John M. ('18; '35), Asst. Engr., Charge Designing & Estimating, R. D. Cole Mfg. Co.; *for mail,* 32 W. Washington St.

PALMETTO, Atlanta Section

BARNES, Charles Arnold (J'35).

ROME, Atlanta Section

ARCHER, Edw. G. ('31), M. E., Charge Design & Research, Tubize Chatillon Corp.; *for mail,* 124 Chatillon Rd.
COOPER, Wilfrid B. (J'24), Research Engr., Tubize Chatillon Corp.

SAVANNAH, Savannah Section

ARTLEY, Will H. (A'29), Pres., Artley Co., 504 E. Bay St.
HUNT, Robt. ('23), M. E., Seaboard Air Line Ry.
JOHNSON, Clement O. (J'30), Lab. Asst. to Tests Engr., Cent. of Ga. Ry.; *for mail,* 205 W. 38th St.
KEHOE, Daniel E. ('16; '35), Engr. Foreman, Ft. Pulaski Natl. Monument; *for mail,* 1225 E. 48th St.
KEISKER, A. P. (A'29), Mgr., Crane Co., 14 W. Broad St.
KNOTT, F. W. ('33), M. M., Seaboard Air Line Ry.
MERCER, Geo. A., Jr. ('23; '31), V. P. & Treas., Steel Products Co., P. O. Box 1007; *for mail,* 333 E. 44th St.
ORMOND, Alex M. ('23), Savannah Sugar Refinery.
ROESEL, L. C. ('22; '26; '35), Supvg. Engr., Ga. Ice Co., 431 Harmon St.; *for mail,* 1301 E. 47th St.
SAMS, Bruce J. ('25; '35), Dist. Engr., So. Cotton Oil Co.; *for mail,* 526 E. 41st St.
SPRAGUE, Benj. O. ('13), Pres., Savannah Sugar Refining Corp., Savannah Bank & Trust Bldg.
SPRAGUE, Wm. W. ('28), Gen. Supt., Savannah Sugar Refining Corp., Savannah Bank & Trust Bldg.

SHANNON, Atlanta Section

KELLY, Timothy J. ('13), V. P. Charge Opera., So. Brighton Mills.

THOMASTON, Atlanta Section

BOESCH, J. C., Jr. (J'36), 209 E. Gordon St.

THOMASVILLE

MATHEWS, H. M. (J'34), Plant Engr., Water & Light Dept., City of Thomasville.

VALDOSTA, Savannah Section

EAGER, Wm. G. ('13; '14; '18), Cons. Engr., Dalton Bldg.

HAWAII, TERRITORY OF

HONOLULU, Oahu

CASTLE, Saml. N. ('09; '11), Kalanianaole Highway.
COULSON, Harry Glen ('28), Field Engr., C. M. Lovested & Co. (Hawaii) Ltd., 26 S. Queen St.; *for mail,* 3021 Vista Pl.
DEVOY, Edmund B. ('22; '35), Ch. Engr., Charge Constr. & Maint., Hawaiian Hotels, Ltd., Royal Hawaiian Hotel.
EWART, Arthur F. ('17; '35), Mgr., Hawaiian Div., Honolulu Iron Wks. Co.; *for mail,* 2370 Nuuanu St.
FOLEY, Walter J. ('10; '23), M. E., Charge Maint. & Design, Hawaiian Dredging Co., Ltd., 854 Kaahumanu St.; *for mail,* 2379 Ala Wai Blvd.
GRAY, P. S. (J'35), Sales Engr., H. S. Gray Co., 74 S. Queen St.; *for mail,* P. O. Box 3016.
HAHN, Albert P. ('28; AM'35), Mgr., Hawaiian Branch, Edw. R. Bacon Co., P. O. Box 379; *for mail,* P. O. Box 637.
HALL, Wm. G. ('13), Gen. Mgr., Honolulu Iron Wks. Co.
HOYT, Simes T. ('23; '35), Cons. Engr., Plantation Dept., Castle & Cooke, Ltd., Merchant St.; *for mail,* 1075 Spencer St.
JOHNSON, Ralph Blake (J'36), 2203 Round Top Dr.
JONES, Edw. S. ('19), Ch. Engr., Opera., Maint. & Constr., Honolulu Gas Co., Ltd., 75 S. King St.
KOLBE, Robt. E. (J'35), Wake Island, c/o Pan Am. Airways System.
McKAY, Wm. M. ('18), Mar. Surveyor, 307 Hawaiian Trust Bldg; *for mail,* 1024 Green St.
METTLER, Chas. G. ('19), Commanding Officer, Hawaiian Ord. Depot.
OLSON, Emil (J'29), Ch. Oper. Engr., Hawaiian Elec. Co., Ltd.
RAMSAY, Wm. A. ('17), Pres., W. A. Ramsay, Ltd., Box 1721.
RUSHO, Ernest J. (J'34), Jr. Hyd. Engr., U. S. Geol. Survey, 225 Fed. Bldg.
SCRIBNER, Charles W. ('89), 64 Judd St.
SHERMAN, Karl M. (J'30), Asst. Maint. Engr., Hawaiian Elec. Co. Ltd.
SMITH, Wm. Earhart ('08; '18), Ch. Boiler Inspc., Hawaiian Sugar Planter's Assoc., P. O. Box 411.
TADDIKEN, John F. ('07; '23), V. P. & Gen. Mgr., Honolulu Iron Wks. Co.
TERRY, Seymour ('20), Works Mgr., Honolulu Iron Works Co.
WALKER, Sidney G. ('07), Fire Protection Engr., 424 Dillingham Transportation Bldg., P. O. Box 2657.
WASSON, John W. (J'25), Engrg. Sales, Von Hamm-Young Co., Ltd., P. O. Box 2630.
YOUNG, John Mason ('02; '10), Prof. Engrg., Univ. of Hawaii, also Pres. & Mgr., Pac. Engrg. Co., Ltd.; *for mail,* P. O. Box 638.

PEARL HARBOR, Oahu

HADLEY, Frank L. ('19), Supt., Cent. Power Plant, Indus. Dept., U. S. Navy, Pearl Harbor; *for mail,* 2624 Makiki Heights, Honolulu.
NICHOLS, Jas. H. ('33), Supvr., U. S. Navy Yard, Pearl Harbor; *for mail,* 1589 Thurston Ave., Honolulu.
TAYLOR, Edwin J., Jr. (J'32), Lieut., U. S. N., Ship Supt., Navy Yard.

PUUNENE, Maui

WALKER, John Edgar ('26; '33; '35), Supt. of Trans., Hawaiian Commercial & Sugar Co.; *for mail,* Box 83.

WAIPAHU, Oahu

GREENE, Ernest W. ('12; '13; '35), Mgr., Oahu Sugar Co., Ltd.

IDAHO

BOISE

BACHELLER, A. W. (J'35), M. E., Air-Conditioning, Mine Mchy. Design, Sawtooth Co., 710 Front St.; *for mail,* 217 N. Walnut St.

IDAHO FALLS

LOTT, Howard Peter (J'33), Engr., Utah Idaho Sugar Co.; *for mail,* R. F. D. 1.

JEROME

DALEY, Robt. E. (J'35).

KELLOGG, Inland Empire Section

PORTER, Fred'k P. ('27), 423 McKinley Ave.

LEWISTON, Inland Empire Section

BRASCH, Ernest F. (J'32), M. E., Potlatch Forests, Inc., Lewiston, Idaho; *for mail,* 445—11th St., Clarkston, Wash.
O'BRYAN, Gordon C. (J'35), Supvr., Surveying Party, Office of Nez Perce Country Agri. Agt., County Court House; *for mail,* 2318 Main St.

MOSCOW, Inland Empire Section

GAUSS, Henry F. ('26), Head Dept. M. E., Univ. of Idaho; *for mail,* 214 N. Polk St.
HALL, Stanley R. (J'35), Instr., Univ. of Idaho; *for mail,* 319 E. 2nd St.
MENEELY, Erle N. (J'36), 922 S. Washington St.
MERCER, Elwyn J. (J'36), Graduate Wk., Univ. of Idaho; *for mail,* 218 S. Asbury.

POCATELLO

GOUGH, A. C. ('18), Dir. of Engrg., Univ. of Idaho, So. Branch; *for mail,* P. O. Box 1045.

TWIN FALLS

BREWSTER, Clarence F. (J'36), Student Engr., Amalgamated Sugar Co.; *for mail,* 222—6th Ave., E.

ILLINOIS

ALTON, St. Louis Section

BASSETT, Burdett E. ('21; '31), West. Cartridge Co., E. Alton; *for mail,* 1419 Henry St., Alton.
BUXTON, Paul H. ('31), Ch. Engr., West. Cartridge Co., E. Alton; *for mail,* 702 Euclid Pl., Alton.
DUNCAN, Wm. M. ('11), Pres., Ill. Stoker Co., 102 W. 7th St.
GRUBE, Donald E. (J'27), Engr., Charge Power, Owens-Ill. Glass Co., Toledo, Ohio; *for mail,* 607 Henry St., Alton, Ill.
HOLLIS, R. Frank ('35; '35), Ch. Engr., Alton Box Board & Paper Co.; *for mail,* 629 E. 15th St.
KIPP, Leonard ('34), Brass Engr. (Maint. & Design), West. Cartridge Co., E. Alton; *for mail,* 417 E. 7th St., Alton.
OLIN, F. W. (A'95), Pres., Equitable Powder Mfg. Co., West. Cartridge Co., E. Alton; *for mail,* 1128 State St., Alton.
OLIN, Spencer T. ('26; '28; '35), Secy.-Treas., West. Cartridge Co., E. Alton.
ROHRICH, Harold A. ('29), Design Supvr., Owens-Ill. Glass Co.; *for mail,* 1413 Main St.

ARGO, Chicago Section

JEFFERIES, Fred'k L. ('00; '05), Executive, Corn Products Refining Co., Argo, Cook Co.

AURORA, Chicago Section

BAUMANN, Christopher C. (J'30), Cadet Engr., West. United Gas & Elec. Co., 420 S. River St.; *for mail,* 461 Galena Blvd.
BODINSON, L. W. ('16), V. P., Ch. Engr., Aurora Pump & Mfg. Co.; *for mail,* 310 Grant Pl.
HASSLER, Paul M. ('23), Designing Engr., Richards Wilcox Co., Aurora; *for mail,* R. F. D. 1, Batavia.
HOAG, Wilton F. ('30), Engr., Charge Maint. & Design, Pictorial Paper Package Corp., 232 S. Lake, Aurora; *for mail,* 57 N. Prairie Ave., Batavia.
JANDA, J. F. ('28), Sales Engr. & Mgr. of Conveyor Div., Barber Greene Co.
KENDALL, Myron A. ('16), Ch. Engr., Stephens-Adamson Mfg. Co., Ridgeway Ave.; *for mail,* 715 Garfield Ave.
NASH, Wm. W. (J'36), M. E., Design & Research, Independent Pneumatic Tool Co., State & Claim Sts.; *for mail,* R. F. D. 3, Box 353.
PLACE, Oliver (J'29), M. E., Charge Exper. Dept., Barber Greene Co., W. Park St.; *for mail,* R. 2, Box 152 AA.

BELLEVILLE, St. Louis Section

DAHM, Walter B. ('24; '35), 26 S. 87th St.
HEMPEL, Herbert W. (J'32), M. E., Design, Marsh Stencil Mch. Co., 707 East B St.
ROBERTS, Cary Russell ('33; '35), Captain, Air Corps Reserves, U. S. A.; Asst. Inspr., Aircraft Supplies, Scott Field Air Depot; *for mail,* 409 S. Charles St., Belleville, Ill.

BELLEWOOD, Chicago Section

PILGRIM, Henry James (J'31), 1022 S. 23rd Ave.

BLUE ISLAND, Chicago Section

VAKSDAL, Steinar (J'35), M. M., Maint., Libby, McNeill & Libby, Western Ave., Blue Island; *for mail,* 1708 W. 105th Pl., Chicago.

BRADLEY, Chicago Section

WELINDT, Tage O. (J'30), Tool Designer, David Bradley Mfg. Wks.

BRISTOL, Chicago Section
GREELEY, Mark S. (J'34).

BROOKFIELD, Chicago Section
ZVONECEK, Jos. Willard (J'33), Asst. Ch. Engr., Container Corp. of Am., 900 N. Ogden Ave., Chicago; *for mail*, 3218 Vernon Ave., Brookfield.

CANTON
BAYLOR, J. Edw. (J'33), 217 W. Olive St.

CHAMPAIGN
PENDRAY, Edw. E. ('23), Spec. Rep., Ill. Power & Light Co., 41 E. University St.

CHICAGO, Chicago Section
ABBOTT, Wm. L. ('91; F'36), Manager, '07-'10; President, '26; Retired; 3500 Lake Shore Dr.
ADAMS, Campbell V. ('19; '35), M. E., Asst. to Gen. Mgr., Vulcan Iron Wks., 327 N. Irving Ave.; *for mail*, 2934 Wilson Ave.
ADAMS, E. Eugene ('33), V. P., Research, Pullman Co., 79 E. Adams St.
ADAMS, H. H. ('12), Supt. Shops & Equip., Chicago Surface Lines, 3901 West End Ave.
ALDEN, John L. ('14; '21; '24), Mfg. Engr., Hawthorne Sta., West. Elec. Co., Inc., Chicago; *for mail*, 510 Blackstone Ave., La Grange.
ALDEN, Vern E. ('20; '35), Power Engr., Stone & Webster Engrg. Corp., 33 S. Clark St.
ALGER, Harley C. (J'08), Mgr., Gravure Dept., R. R. Donnelley & Sons Co., 350 E. 22nd St.; *for mail*, 5638 Kenwood Ave.
ALLEN, Col. Henry A. ('00) Cons. Engr., Henry A. Allen Co., 205 W. Wacker Dr.; *for mail*, 3138 Sheridan Rd.
ALLEN, Jean M. ('13), Contrg. & Cons. Engr., Jean M. Allen & Co., 75 E. Wacker Dr.
ALLEN, Wm. Gordon (J'30), 1830 Lunt Ave.
ALLPORT, Hamilton ('23), Partner, McKinsey, Wellington & Co., 135 S. LaSalle St.
AMSTUTZ, J. B. ('21; '27), Leslie F. Muter Co., 8440 S. Chicago Ave., Chicago; *for mail*, 726 S. Euclid Ave., Oak Park.
ANDERSON, Jas. A. ('23), Mem. Natl. R. R. Adjustment Bd., 220 S. State St.
ANDERSON, Oscar A. ('35), Asst. Ch. Engr., Charge M. E., Maint. & Power Plants, Armour & Co., Union Stock Yards; *for mail*, 9830 S. Hamilton Ave.
ANDREWS, Roger W. (A'36), West. Mgr., Combustion Engrg. Co., Inc., Bankers Bldg.
ARMITAGE, Richard F. (J'33), Fuel Engr., Republic Steel Corp., 118th St. & Burley Ave.; *for mail*, 5849 N. Rockwell St.
ARNOLD, Bion J. ('22), Chmn. Bd. Supervising Engrs., Chicago Traction, Suite 1417, 231 S. LaSalle St.
ASHTON, Roger (J'35), 7808 S. Shore Dr.
ASIMOW, Morris (J'35), 1318 Hyde Pk. Blvd.
AUSTIN, Clem C. ('29), Pres., Mancha Storage Battery Loco. Co., 4850 S. Halsted St.
BACON, Robt. H. ('23; '35), V. P., Kreicker & Meloan, Inc., 221 N. LaSalle St.
BAILEY, Alex D. ('10; '16; F'36), Manager, '32-'35; Vice-President, '35-'37; Asst. Ch. Oper. Engr. & Supt. Generating Stas., Commonwealth Edison Co., Rm. 524, 72 W. Adams St.
BALLENTINE, Jas. M. ('19; '35), Mgr. of Wks., Internatl. Harvester Co., 606 S. Michigan Ave.
BALLENTINE, Wm. I. ('12), Chicago Athletic Assn. 12 S. Michigan Ave.
BANASH, Jas. I. ('17), Cons. Engr., 230 N. Mich. Ave.
BARITEAU, Adelard J. ('30; '35), 1130 E. 47th St.
BARTON, A. Radford (J'36), Plant Engr., E. J. Brach & Sons, 4656 W. Kinzie St., Chicago; *for mail*, 844 Washington Blvd., Oak Park.
BATTEY, Paul L. ('22), Pres., Treas., Battey & Kipp, Inc., Suite 2086, 231 S. LaSalle St.
BEALS, Richard O. (J'34), R. R. Donnelley & Sons Co., Chicago; *for mail*, 1006 S. Home Ave., Oak Park.
BECKER, H. Kirke ('19; '35), V. P., Gen. Mgr., Peters Mchy. Co., 4700 Ravenswood Ave.
BECKER, Peter M., Jr. (J'34), M. E., Goodman Mfg. Co., 48th & Halsted Sts.; *for mail*, 5636 S. Throop St.
BECKMAN, Leroy J. (J'35), 5706 S. Justine St.
BECKWITH, E. L. ('20; '35), Dist. Mgr., Detroit Stoker Co., 333 N. Michigan Ave.; *for mail*, 6139 University Ave.
BEHRENS, Henry F. ('22; '25; '35), Mgr. Sales Engrg. Dept., Geo. B. Limbert & Co., 570 Fulton St.
BEMIS, Walter S. ('21; '32), Pres., Bemis Co., Cons. Engrs., 5311 Cornell Ave.
BENDER, Rene J. (J'25), Fuel Oil Engr., Sinclair Refining Co., 2540 W. Cermak Rd.
BENNETT, W. H. K. ('20), Pres., W. H. K. Bennett Co., 57 E. Jackson Blvd.
BENSINGER, Samuel (J'34), M. E., Diesel Eng. Design, Buda Co., Harvey; *for mail*, 5110 Kenwood Ave., Chicago.
BENSON, Chenery F. ('19; '22), Ch. Engr., West. Felt Wks., 4115-33 Ogden Ave.; *for mail*, 1503 E. 67th Pl.
BENTLY, Julius G. ('24; '25; '35), Chief Fuel Engr., Sahara Coal Co., 59 E. Van Buren St.; *for mail*, 7748 East End Ave.
BERGMAN, Donald J. ('24; '35), Ch. Engr., Universal Oil Products Co., 310 S. Michigan Ave.
BERGMANN, Adolph A. ('23; '29), Asst. M. E., Pub. Utility Engrg. & Serv. Corp., 231 S. LaSalle St.
BERRY, Edw. L. ('21; '26; '35), Asst. Gen. Mgr., Link-Belt Co., 300 W. Pershing Rd.; *for mail*, 5807 Dorchester Ave.
BIDWELL, Edgar M. ('23; '35), M. E., West. Elec. Co., Inc., Chicago; *for mail*, 21 Woodstock Ave., Clarendon Hills.
BIEDESS, A. R. (J'30), Engrg. Dept. Foreman, Goodman Mfg. Co., 4834 S. Halsted St.
BIRD, Lee Garrison ('30; '32), Boiler Room Engr., Commonwealth Edison Co., 72 W. Adams St., Chicago; *for mail*, 126 S. Cuyler Ave., Oak Park.
BLACK, Henry M. (J'34), Asst. M. E., Sargent & Lundy, Inc., 140 S. Dearborn St.
BLANCHARD, Philip D. ('28; '36), Superheater Co., 122 S. Michigan Ave.
BLESSING, Wm. Henry ('26; '35), Engr. Sales, Research Corp., 343 S. Dearborn St.
BLOHM, August H. ('17; '35), M. E., Design, Ludlow Typograph Co., 2032 Clybourn Ave.; *for mail*, 1719 N. Austin Ave.
BLOMQUIST, C. A. G., Jr. (J'36), Drafting, Research in Air Conditioning, Pullman Stand. Car Mfg. Co., 11001 Cottage Grove; *for mail*, 11224 Edbrooke Ave.
BOA, R. Geo. C. ('36), Indus. Engr., Frank D. Chase, Inc., 307 N. Michigan Ave.; *for mail*, 3007 Addison St.
BOIES, Harry B. ('18; '29; '35), Indus. Engr., Automatic Transportation Co., 101 W. 87th St.; *for mail*, 10605 S. Wood St.
BONINE, Jas. G. (J'36), 7523½ Coles Ave.
BORN, William G. ('19), Ch. Engr., John Mohr & Sons; *for mail*, 7811 Burnham Ave.
BOYNTON, Arthur J. ('22), V. P., H. A. Brassert & Co., 310 S. Michigan Ave.
BRADAC, Geo. (J'35), 2214 N. Central Ave.
BRIZZOLARA, R. D. ('27; '30), Ch. Engr., Am. Steel Fdys., 410 N. Michigan Ave.; *for mail*, 1000 N. Mansfield Ave.
BROOKS, Chas. C. ('14), West. Mgr., Robins Conveying Belt Co., Rm. 1570, 37 W. Van Buren St.
BROOKS, Saml. A. ('29), Treas., United Conveyor Corp., 37 W. Van Buren St.
BROSSART, J. A., Jr. (J'36), Cadet Engr., Stand. Ry. Equip. Co., 310 S. Michigan Ave.; *for mail*, 5321 Cornell Ave.
BROUSSARD, Jos. (J'35), Checker, Mech. Stands. Dept., Corn Products Refining Co., Argo; *for mail*, 5619 S. St. Louis Ave., Chicago.
BROWN, Geo. Irving (J.'20), Apt. 615, Plaza Hotel, 1553 N. Clark St.
BUCKINGHAM, J. E. ('18; '23), V. P., Charge Sales, Lincoln Elec. Ry. Sales Co., 310 S. Michigan Ave.
BUENGER, Edw. F. ('30), V. P., Charge Mfg., Wilson-Jones Co., 3300 Franklin Blvd., Chicago; *for mail*, 940 N. Linden Ave., Oak Park.
BURKE, Albert G., Jr. ('13), Sales Engr., Hagan Corp., 111 W. Jackson Blvd.; *for mail*, 7527 Essex Ave.
BUSBY, Wm. (J'35), Asst. Plant Engr., Bauer & Black, 2500 S. Dearborn St.; *for mail*, 1633 Estes Ave.
CAMPIONE, Jos. L. (J'33), Steam & Power Engr., Swift & Co., Union Stock Yards; *for mail*, 1946 W. Garfield.
CARLSON, Adolph G. ('17), Ch. Engr., Universal Atlas Cement Co., 208 S. LaSalle St.
CARROLL, Harry C. ('27), Cons. Engr., Dir. M. E. Dept., Commercial Testing & Engrg. Co., 360 N. Michigan Ave.
CHAMBERS, David F. (J'25), Asst. Engr., Erecting Dept., Am. Bridge Co., 208 S. LaSalle St., Chicago; *for mail*, 4509 Main St., Downers Grove.
CHAMPION, Edw. L. (J'23), Ingersoll-Rand Co., 400 W. Madison St.
CHARLES, Carl L. ('28), Spec. Engr., Barco Mfg., Co., 1801 Winnemac Ave., Chicago; *for mail*, 1088 Elm St., Winnetka.
CHARTER, Jas. A. ('99), Pres., Charter Drive, Inc., 111 W. Monroe St.; *for mail*, 1201 Chase Ave.
CHRISTIANSON, Andrew ('07), Ch. Engr., Pullman-Stand. Car Mfg. Co., 11001 Cottage Grove Ave.
CHUN, Edwin Hin Jung (J'32), 2317 Wentworth Ave.
CLARK, Albert B. ('15), M. E., Sargent & Lundy, Inc., 140 S. Dearborn St.
CLARKE, Warren H. (J'21), Cons. Engr., Warren H. Clarke & Co., 120 S. LaSalle St.
CLAYPOOLE, Albert ('27), 2625 E. 74th St., S. Shore Sta.
CLAYTON, J. Paul ('11; '26), Ch. System Officer, Edison Bldg., 72 W. Adams St., Chicago; *for mail*, 1153 Pine St., Winnetka.
CLUCAS, Geo. W. ('15; '35), Secy., Engr., Stand. Power Equip. Co., Rm. 925, Monadnock Block.
COHEN, Alvin E. (J'35), Engr., Charge Design, Brady Conveyors Corp., 20 W. Jackson Blvd.; *for mail*, 4944 N. Kimball Ave.
COLE, C. B. ('19; '26), Pres., Engrg. & Sales, Tool Equip. Sales Co., 4625 Fulton St., Chicago; *for mail*, 165 S. Delaplaine Ave., Riverside.
COLE, Kenneth W. ('24; '35), Dist. Mgr., Pressed Steel Tank Co., 208 S. LaSalle St.
COLE, Sidney I. ('28; AM'34), V. P., M. E., Charge Sales & Constr., Indus. Erectors, 188 W. Randolph St.; *for mail*, 3428 W. Monroe St.
COLEMAN, Ernest L. (A'22), Mgr., Indus. Dept., Peat, Marwick, Mitchell & Co., 105 S. LaSalle St.
COLSTON, Robt. ('21; '21; '35), Dist. Rep., Hagan Corp., Hall Labs., Inc., 111 W. Jackson Blvd.
COOPER, R. Dunham, ('24; '35), M. E., Charge Maint. & Supt. of Power, Union Stock Yd. & Transit Co., Union Stock Yds.
COOPER, Roland S. ('24; '35), Dist. Mgr., Indus. Dept., Superheater Co., 122 S. Michigan Ave.
CORELL, Geo. W. (J'33), 5704 N. Karlov Ave.
CORNWELL, David R. L. (J'32), Asst. Credit Mgr., C. F. Pease Co., 813 N. Franklin St., Chicago; *for mail*, 429 N. Harvey Ave., Oak Park.
COTTERMAN, Frank D. (J'36), 4716 N. Hermitage Ave.
COTTLE, A. P. ('35), Chmn., Matls. Com., Internatl. Harvester Co., 606 S. Michigan Ave.
CRAFTS, Curtis S. ('34), Ch. Engr., Goss Ptg. Press Co., 1535 S. Paulina St.
CRANE, Edw. J. ('25), Dept. Ch., Mch. Design, Div., West. Elec. Co., Inc., Chicago; *for mail*, 741 S. Oak Park Ave., Oak Park.
CRAWFORD, Perry O. ('25), Pres., Admin., Am. Utilities Serv. Corp., 214 Main St., Savanna, Ill. & 231 S. La Salle St., Chicago, Ill. (*former address for mail*).
CROSS, Harold W. ('20), Engr., Turbine Sales, Gen. Elec. Co., 230 S. Clark St.
CROSS, Wallace J. ('14; '21), Ch. Draftsman, Engrg. Dept., Sinclair Refining Co., E. Chicago, Ind.; *for mail*, 6612 Minerva Ave., Chicago, Ill.
CULVER, Henry F. ('26; '32; '35), M. E., Hawthorne Sta., West. Elec. Co., Inc.
CUNNINGHAM, Jas. D. ('18; '21; F'36), Manager, '29-'32; Vice-President, '32-'34; Pres., Republic Flow Meters Co., 2240 Diversey Pkwy.
CUNNINGHAM, John Symonds (J'33), 5052 S. Ellis.
CZAJKOWSKI, Edw. C. (J'34), 1807 Victoria St., N. Chicago.
DAHLGREN, Carl E. (J'34), 1100 N. LaSalle St.
DALZIEL, Philip S. (J'35), Engrg. Dept., Binks Mfg. Co., 3114 Carroll Ave.
DARLINGTON, Jos. F. ('26), Cons. Engr. & Oper. Mgr., Winston & Co., 38 S. Dearborn St.; *for mail*, 8106 Paxton Ave.
DARRAH, Wm. A. ('19), Pres., Continental Indus. Engrs. Inc., 201 N. Wells St. Chicago; *for mail*, 901 N. Oak Park Ave., Oak Park.
DART, Thos. P. (J'34), 4247 N. Hermitage Ave.
DAVIS, Emmett L. ('21; '29), Sales Engr., Raymond Bros. Impact Pulverizer Co., 1319 N. Branch St.; *for mail*, 1339 Elmdale Ave.
DAVIS, Harold R. (J'32), Exper. Tester, Tractor Wks., Internatl. Harvester Co., 2600 W. 31st Blvd.; *for mail*, 356 E. 73 St.
DAVIS, Homer S. (J'25), Circulation Accountant (in charge), Chicago Herald & Examiner, 326 W. Madison St.
DAVIS, Russell G. ('21; '25; '35), Dist. Mgr., Charge Sales, Chain Belt Co., 2240—20 N. Wacker Dr.
DEBOO, Jos. H. (J'35), 1310 N. Springfield Ave.
DENMAN, Burt J. ('13), V. P. & Gen. Mgr., United Light & Power Co., 105 W. Adams St.
DERBY, Malcolm R. (J'32), Engr., Sonner Burner Co., 122 S. Michigan Ave.; *for mail*, 1430 Greenleaf Ave.
DEWEY, Wm. V. (J'30), Engr., Advisor to Sales Dept., Natl. Carbon Co., 230 N. Michigan Ave.
DEWOLFE, Edw. C. ('99; A'06), Prop., DeWolfe Indus. Adv., 608 S. Dearborn St.
DIEMER, Hugo ('04), Dir. Mgmt. Courses & Personnel, LaSalle Ext. Univ., 4101 S. Michigan Ave.
DILLON, Jos. H. ('28), Ch. Engr., Wisconsin Steel Wks., 106th & Torrence Ave.; *for mail*, 7621 S. Shore Dr.
DODGE, Arthur Chas. (A'19), Fairbanks, Morse & Co., 900 S. Wabash Ave.
DOLESH, Frank J. (J'34), Indus. Engr., F. J. Brach & Sons, 4656 W. Kinzie St.; *for mail*, 5829 W. Fulton St.
DOMANTAY, Francisco J. (J'30), 915 Cornelia Ave.
DOPP, Carl A. ('28), Product Engr., Crane Co., 836 S. Michigan Ave.
DORÉ, A. J. (J'35), Time Study Engr., Teletype Corp., 1400 Wrightwood Ave.; *for mail*, 208 N. Latrobe Ave.

DREFFEIN, Henry A. ('13), Pres., Flinn & Dreffein Co., 308 W. Washington St.
DRUCKER, Albert (J'22), Engr., Charge Design, Prod., Burke & James, Inc., 223 W. Madison St.
DRUMMOND, Warren C. ('28), Mech. Oper. Engr., Byllesby Engrg. & Mgmt. Co., 231 S. LaSalle St., Chicago; *for mail,* 610 Hinman Ave., Evanston.
Du CHATEAU, Manuel F., Jr. (J'36), Sales Engr., Crane Co., 41st & Kedzie Sts., Chicago; *for mail,* 2615 S. Cuyler Ave., Berwyn.
DUDLEY, Edw. F. ('18; '35), Engr., Charge Design, Miehle Printing Press & Mfg. Co., 2011 Hastings St., Chicago; *for mail,* 326 Wesley Ave., Oak Park.
DULL, Raymond W. ('08), Cons. Contrg. Engr., 9 S. Clinton St., Chicago; *for mail,* 201 S. La Grange Rd., La Grange.
DUNIGAN, Edw. B. (A'30), Catalog Prod. Mgr., Sears Roebuck & Co., Chicago; *for mail,* 140 S. Euclid Ave., Oak Park.
DUTCHER, John E. ('22), M. E., Schmidt, Garden & Erikson, 104 S. Michigan Ave.
EAST, Warren Errett ('19; '35), Sales Engr., Babcock & Wilcox Co., 140 S. Dearborn St.
EATON, Wyman ('26), Pres., Freyn Engrg. Co., 310 S. Michigan Ave.; *for mail,* 7340 Merrill Ave.
EBNER, Alfred J. ('26), Asst. V. P., Freyn Engrg. Co., Chicago; *for mail,* 384 S. Washington St., Elmhurst.
EDERER, Lothar A. ('31), Treas. & Wks. Engr., R. J. Ederer Co., 540 Orleans St.
EICHIN, Harry P. (J'28), Mch. Designer, Visking Corp., 6733 W. 65th St.
EKLIND, Carl E. ('19), Asst. V. P., Camel Sales Co., Rm. 1610, 332 S. Michigan Ave.
ELLISON, Lewis M. ('11; '13), Pres., Ellison Draft Gage Co., 214 W. Kinzie St.
ELMER, Nixon W. ('15), Redler Engr., Salesman, Stephens-Adamson Mfg. Co., 360 N. Michigan Ave., Chicago; *for mail,* 201 S. Taylor Ave., Oak Park.
ELMES, Chas. W. ('04), Pres., Chas. F. Elmes Engrg. Wks., 230 N. Morgan St.
ELWOOD, Calvin A. (J'33), M. E., Charge Lub., Republic Steel Corp., 118th St. & Borley; *for mail,* 10718 Church St.
ENES, J. T. ('18; '35), Asst. Dist. Engr., Youngstown Sheet & Tube Co., E. Chicago, Ind.; *for mail,* 7443 Rhodes Ave., Chicago, Ill.
ERICKSON, Alfred C. (J'33), Instr., Mch. Drawing & Design, J. Sterling Morton High Sch., Cicero; *home address,* 10 S. Mason St., Chicago.
ERICKSON, Eric A. (J'34), Inspr., Am. Can Co., 6005 S. Western Ave.; *for mail,* 8019 St. Lawrence Ave.
ERICKSON, Robt. (J'27), M. E., Methods, Simonds Saw & Steel Co., 1624 S. Western Ave.
EVANS, Melvin J. ('17; '23; '26), Chmn., Evans Associates, Inc., 225 N. Michigan Ave., Chicago; *for mail,* Flossmoor.
EVANS, W. I. ('30), 3400 N. California Ave.
EVARTS, Ralph E. ('27; '35), 30 W. Chicago Ave.
EWERT, Wm. A. ('21; '27; '35), Engr., Charge Indus. Engrg., Frank D. Chase, Inc., 307 Michigan Ave., Chicago; *for mail,* 4910 W. 24th St., Cicero.
FANKBONER, Harland ('27), 1317 Greenleaf Ave.
FARRAND, Edmund G. ('29; '35), Secy., Gen. Mgr., United Conveyor Corp., 37 W. Van Buren St.
FATHAUER, Carl E. (J'32), Draftsman, Hubbard Oven Co., 1134 Belden Ave.; *for mail,* 457 Roslyn Pl.
FERGUSON, John F. ('31), Ferguson Engrs., 53 W. Jackson Blvd.
FERGUSON, Louis A., Jr. ('21; '35), Customer's Serv. Mgr., Commonwealth Edison Co., 72 W. Adams St.
FEUCHTER, Robt. ('27; '35), Ch. Engr., Chas. F. Elmes Engrg. Wks., 230 N. Morgan St.; *for mail,* 1030 N. Dearborn St.
FINNEGAN, Jos. B. ('20), Prof. Fire Protection Engrg., Armour Inst. of Tech., 3300 Federal St.
FISCHER, Herbert O. A. (J'33), 8323 S. Paulina St.
FISCHMAN, Saml. O. (J'33), Sr. Time Study Engr., Rudolph Wurlitzer Co., DeKalb; *for mail,* 1868 S. Millard Ave., Chicago.
FISHER, Fred F. ('30), Plant Engr., Ingersoll Steel & Disc Co., 1030 W. 120th St.
FISHER, Fred'k ('18; '35), Pres. Gen. Mgr., R. E. Ellis Engrg. Co., 621 Washington St.
FLEMING, Thomas F. (J'36), Safety Engr., Liberty Mutual Ins. Co., 122 N. 7th St., St. Louis, Mo.; *for mail,* 7004 Eggleston Ave., Chicago, Ill.
FLESHER, M. G. ('28; '35), Combustion Engrg., Westinghouse Elec. & Mfg. Co.; *for mail,* 11721 Longwood Dr., Morgan Park.
FLINN, Melville S. ('13), Secy., Treas., Flinn & Dreffein Co., 308 W. Washington St.
FOLSE, J. A. ('32), Curator, Dept. of Power, Museum of Sci. & Indus., 57th St. & the Lake.
FOTTER, Millard J. (J'35), 4650 N. Crawford Ave.
FRALICH, John S. Y. ('16; '23), Dist. Engr., Westinghouse Air Brake Co., 80 E. Jackson Blvd.
FRANKENHOFF, Eugene T. ('35; '35), Sales Engr., Dicalite Co., 520 N. Michigan Ave.
FRASER, Norman D. ('86), Retired; 69 W. Washington St.
FREAS, R. B. (J'24), Pres., Freas Thermo-Elec. Co., 1736 N. Springfield Ave.
FREIMAN, Edw. P. (J'36), Asst. Foreman, Assembly Line, Wilson & Bennet Mfg. Co., 6532 S. Menard Ave.; *for mail,* 2212 Cleveland Ave.
FRENCH, Dudley K. ('28), Dir., Chem. Engr., Dudley K. French & Associates, 3250 Archer Ave., Chicago; *for mail,* 503 Hawthorn Lane, Winnetka.
FREYN, Henry J. ('06), Pres., Freyn Engrg. Co., Rm. 1638, 310 S. Michigan Ave.
FROBERG, Harold G. (J'29), Watch Boiler Rm. Engr., Commonwealth Edison Co., 72 W. Adams St.; *for mail,* 5548 Shields Ave.
FRY, Albert H. ('31; '35), Engr., Meter Dept., Ill. Maint. Co., Rm. 1136, 72 W. Adams St.
GAFFERT, Gustaf Adolf ('23; '30; '35), Asst. M. E., Charge Mech. Design, Sargent & Lundy, Inc., Rm. 1600, 140 S. Dearborn St.
GAINES, E. C. ('17; '18), Engr., Mead Morrison Div., Robins Conveying Belt Co., 37 W. Van Buren St.; *for mail,* 5054 Winthrop Ave.
GALLENKAMP, Edw. W., Jr. ('21), Engr., Charge Constr. & Opera., Beatrice Creamery Co., 1526 S. State St.
GALLUP, Rockwell L. ('18), Designer, Cameron Can Mchy. Co., 240 N. Ashland Ave.; *for mail,* 2939 Leland Ave.
GARBE, Howard W. (J'32), Engr., Charge Devel. & Testing, Precision Scien. Co., 1750 N. Springfield Ave.; *for mail,* 7916 Birchdale Ave.
GARLAND, Claude M. ('06; '12), Pres., C. M. Garland & Co., Inc., Cons. Engrs., 38 S. Dearborn St.
GARTZ, Wm. J. (J'36), 15 N. Keeler Ave.
GAYTON, Loran D. ('24), Acting City Engr., City of Chicago, 402 City Hall.
GEARON, Gerald ('27), Supvg. Mech. Engrg. Dept. for Inspc. Steam Boilers & Cooling Plants, Rm. 601, City Hall.
GELZER, Eric ('22; '35), 1446 Thorndale Ave.
GIFFORD, Robt. L. ('02), Pres., Ill. Engrg. Co., Cor. 21st St. & Racine Ave., Chicago, Ill.; *for mail,* 1231 El Molino Ave., Pasadena, Calif.
GILROY, John A. (J'34), Spec. Engr., Ill. Cent. System, 135 E. 11th Pl.; *for mail,* 9649 S. Hamilton Ave.
GLADDEN, Chas. S. ('01; '25), M. E., Combustion Engrg. Co., 1930 Bankers Bldg.
GOELZ, Arnold H. ('14; '35), Pres., Treas., Kroeschell Engrg. Co., 215 W. Ontario St.
GOETZ, Billy E. ('34; '35), Instr., Armour Inst. of Tech.
GOLBER, Myron B. (J'29), Indus. Engr., Armour & Co., Union Stock Yards; *for mail,* 5218 Woodlawn Ave.
GOLDBERG, Chas. K. (J'35), Draftsman, Clearing Mch. Corp., 6499 W. 65th St.; *for mail,* 925 W. 63rd St.
GOLDBERG, Herman ('35), Propr., Snow Mfg. Co., 4636 W. Fulton St.
GOLDSMITH, Clarence ('11), Asst. Ch. Engr., Natl. Bd. Fire Underwriters, Rm. 953, 222 W. Adams St.
GOLLIN, Chas. (J'33), Application Engr., Minneapolis-Honeywell Regulator Co., 43 E. Ohio St.; *for mail,* 908 E. 53rd St.
GORDON, Chas. W. ('21; '25; '35), M. E., Raymond Bros. Impact Pulverizer Co., 1319 N. Branch, Chicago, Ill.; *for mail,* R. F. D. 1, Hammond, Ind.
GORDON, Elliott M. (J'35), Engr., Ernst & Ernst, 231 S. LaSalle St.
GRAHAM, W. M. (J'33), Jr. Engr., Swift & Co., Union Stock Yards; *for mail,* 709 W. 68th St.
GRAU, Howard L. (J'28), Engr., Steam Effic., Commonwealth Edison Co., Rm. 728, 72 W. Adams St.
GREEN, Walter H. ('16), V. P., Internatl. Filter Co., 59 E. Van Buren St.
GREEN, Wm. O. ('91), Partner, Ogden, Sheldon & Co., 30 N. LaSalle St.
GREENBERG, Morris ('19; '28), Bailey Meter Co., 20 N. Wacker Dr.
GREENBLATT, Louis Wm., Jr. (J'35), 1322 Sherwin Ave.
GREENHILL, Harold ('29), Gen. Mgr., Wm. P. Greenhill & Son, 500 W. Division St.
GREENNAN, Edwin G. ('07; '13), Pur. Engr., R. R. Donnelley & Sons Co., 731 Plymouth Pl.; *for mail,* 3514 Franklin Blvd.
GREENMAN, Hugh M. (J'36), 3514 Franklin Blvd.
GROUNDWATER, Wm. H. (J'34), Engr., Design & Maint., Gen. Am. Transportation Corp., 135 S. LaSalle St.
GRUNERT, Arthur E. ('15; '21; '28), *Melville Medallist,* 1931; Supt., Generating Stas., Commonwealth Edison Co., 22nd & Fisk Sts.
HADDEN, A. A. ('34), Partner, McClure, Hadden & Swisher, 111 W. Washington St.
HAFER, G. P. (J'34), 3210 Arthington St.
HAGERMAN, Oliver S. ('25; '35), Am. Light & Traction Co., Suite 2200, 105 W. Adams St.
HAGUE, Harold O. ('21; '35), M. E., Allbright Nell Co., 5323 S. Western Blvd.; *for mail,* 11117 Lowe Ave.
HALL, J. M. ('33), M. E., Cardwell Westinghouse Co., 332 S. Michigan Ave.
HALL, Leo G. ('21; '24), Designing Engr., Roberts & Schaeffer Co., 1110 Wrigley Bldg.
HALLER, Frank, Jr. (J'35), Research Engr., Crane Co., 4100 Kedzie Ave.; *for mail,* 2511 S. Central Park Ave.
HAMILTON, Donald B. (J'36), Asst. Engr., Petersen Oven Co., 300 W. Adams St.; *for mail,* 7819 S. Peoria St.
HAMILTON, T. M. (J'30), Buyer, Mech. & Elec. Equipment, Tribune Co., Rm. 1214, Tribune Tower, Chicago; *for mail,* 520 Fair Oaks Ave., Oak Park.
HAMMOND, Ewd. K. ('19), West. Mgr., Indus. Press, 228 N. LaSalle St.
HANNUM, Joshua Eyre ('19; '35), Assn. of Am. Railroads, 59 E. Van Buren St.
HANSSEN, Stan L. ('21; '35), Secy., Treas., Hanson Scale Co., 525 N. Ada St.
HARNSBERGER, Audley E. ('22; '28; '35), M. E., Charge Refinery Dept., Pure Oil Co., 35 E. Wacker Dr.
HARPER, John H. (J'25), Engr., Charge Design, Fansteel Metallurgical Corp., N. Chicago.
HARPER, Philip S. (J'17), Pres. & Mgr., Harper-Wyman Mfg. Co., 8562 Vincennes Ave.
HARSCHNEK, Robt. A. (J'29), Engr., Swift & Co., Union Stock Yards; *for mail,* 4543 N. Lincoln St.
HART, Earle L. ('27; '35), Earle Hart Woodworking Mch. Co., 565 W. Washington Blvd.
HARZA, Leroy Francis ('19), Cons. Engr., Pres., Harza Engrg. Co., 205 W. Wacker Dr., Chicago; *for mail,* 2299 Pierce Rd., Highland Park.
HASSE, Frank C. ('36), Gen. Mgr., Oxweld R. R. Serv. Co., 230 N. Michigan Ave.
HAUSMANN, Louis ('36), Steam Power Engr., Westinghouse Elec. & Mfg. Co., 20 N. Wacker Dr.; *for mail,* 6747 Chappel Ave.
HAWKINS, Ralph R. ('28), M. E., West. Elec. Co., Inc., Div. 6443, Chicago; *for mail,* 3432 Arden Ave., Hollywood.
HAWLEY, Wm. P. ('03; A'10), Prof. M. E., Emeritus, Lewis Inst., 1951 W. Madison St., Chicago; *for mail,* 320 N. Ridgeland Ave., Oak Park.
HAYNES, Jas. L. ('14; '23), Div. Engr., Hyatt Roller Bearing Co., 180 N. Michigan Ave.
HEALD, Geo. W. ('19), Ch. Engr., Design & Constr., Ramtite Co., 2563 W. 18th St.; *for mail,* 2004 W. 102nd St.
HEBBERD, Loren L. ('12; '15; '24), c/o D. H. Skeen & Co., Rm. 2065, 1 LaSalle St.
HEBLEY, Henry F. ('24; '32), Engr., Charge Coal Preparation, Commercial Testing & Engrg. Co., 360 N. Michigan Ave.; *for mail,* 636 Wrightwood Ave.
HEINZE, Wm. Alex ('33; '35), Engr., Charge Mech. Research, Victor Gasket & Mfg. Co., 5750 Roosevelt Rd.; *for mail,* 4817 N. Leavitt St.
HELLA, Robt. (J'35), 7619 Bosworth Ave.
HENDERSEN, Thorvald Edgar (J'36), Mill Investigator, Carnegie-Ill. Steel Corp., 3426 E. 89th St.; *for mail,* 7934 Kingston Ave.
HENDRICKSON, Geo. S. ('20; '35), V. P., Charge Sales, Republic Flow Meters Co., 2240 Diversey Pkwy.
HENNING, Chas. F. ('17), V. P., Charge Sales, U. S. Gypsum Co., 300 W. Adams St.
HENNING, Wm. W. (J'35), 4701 N. Knox Ave.
HENRY, Earle G. ('31), Exper. Machinist, Mills Novelty Co.; *for mail,* 6061 Neva Ave.
HIGGINS, Jas. E. (J'30), 5644 S. Artesian Ave.
HIGGINSON, Edmund E. ('34), Plant Engr., M. M. Olson Rug & Carpet Mfg. Co., 2800 N. Crawford Ave.
HILL, Ernest K. ('18; '24; '35), M. E., Pat. Atty., Chas. W. Hills, 1414 Monadnock Bldg.
HILL, R. J. (A'04), 5027 Dorchester Ave.
HODSON, Walter D. ('29), Pres. & Gen. Mgr., Hodson Corp., 5301 W. 66th St.
HOFFMAN, Wm. Chas. (J'33), Draftsman, Barrett Cravens Co., 3255 W. 30th St.; *for mail,* 6622 S. Maplewood Ave.
HOGE, Fred'k H. ('21), V. P., Charge Engrg. & Sales, W. A. Jones Fdy. & Mch. Co., 4401 Roosevelt Rd., Chicago; *for mail,* 604 Lyman Ave., Oak Park.
HOGLUND, Frank W. (J'28), Test Engr., Chicago Dist. Elec. Generating Corp.; *for mail,* 7515 Evans Ave.
HOLLENBERGER, Theo. J. ('12; '25), Heat & Vent. Engr., Arch. Dept., Bd. of Education, 228 N. LaSalle St.
HOLMES, J. A. ('32; '35), Dir. Serv., Natl. Aluminate Corp., 6216 W. 66th Pl.
HOLPER, Armin E. ('26; '35), 3321 N. Crawford Ave.
HOOVER, H. Earl ('20; '23), V. P., Charge Patents, Engrg. & Research, Hoover Co., 8 S. Michigan Ave.
HORMELL, Duane C. ('22; '35), Asst. M. E., Byllesby Engrg. & Mgmt. Corp., 231 S. LaSalle St.

HORSTMANN, F. B. ('30), Chem. Engr., Asst. to V. P., Dearborn Chem. Co., 310 S. Michigan Ave.
HOSBEIN, Louis H. ('17; '22), Treas., Gen. Mgr., M. H. Detrick Co., Rm. 930, 140 S. Dearborn St.
HOUSE, C. M. ('34), Supt., Alton R. R. Co., 340 W. Harrison St.
HOUSER, Arthur M. ('12), Engr., Standardization, Crane Co., 836 S. Michigan Ave.
HOUSTON, Albert J. R. ('21; '34), *Student Award*, '21; Engr., Harza Engrg. Co., 205 W. Wacker Dr.
HOWARTH, Jacob M. ('13; '21; '35), Asst. Ch. Engr., Marshall Field & Co., 121 State St.; *for mail*, 1303 Glenlake Ave.
HOWELL, S. S. ('11), Cons. Engr., 608 S. Dearborn St.; *for mail*, 1041 Rush St.
HOWSAM, Hilyard C. ('31; '35), Supt., Hubbard Spool Co., 1622 Carroll Ave.
HOWSON, L. R. ('29), Partner, Alvord, Burdick & Howson, Suite 1401, 20 N. Wacker Dr.
HOYER, Wm. A. (J'34), 1163 E. 63rd St.
HULBERT, Wm. R. ('06; '12), Pres., Htg. Equip. Co. of Am., 6 N. Michigan Ave.
HUNGERFORD, Warren H. ('19; '25), Cons. Engr., 221 N. LaSalle St.
HUNT, Franklin B. ('24; '34), Ch. Engr., Liquid Carbonic Corp., 3100 S. Kedzie Ave.
HUSTER, Richard A. (J'34), 2035 Estes Ave.
IRELAND, Thos. H. ('27), Crane Co., 836 S. Michigan Ave.; *for mail*, 1309 Fargo Ave.
JACKSON, D. C., Jr. ('23; '28), Dir., Lewis Inst., 1951 W. Madison St.
JACQUES, Stanley A. ('20; '25; '35), Engr., Republic Flow Meters Co., 2240 Diversey Ave.; *for mail*, 5148 Carmen Ave.
JAGDMANN, Edwin F. (J'36), Dredge Inspr., U. S. Engr. Office, 91st St. & Calumet River; *for mail*, 5040 Cullom Ave.
JENS, Arthur H. (J'35), Fire Protection Engr., Springfield Fire & Marine Ins. Co., 222 W. Adams St.; *for mail*, 7407 N. Ashland Ave.
JENSEN, Joe W. (J'34), Charge Devel. & Exper. Dept., Hurley Mch. Co., 54th Ave. & 22nd St.; *for mail*, 501 N. Central Ave.
JENSEN, Sigurd R. ('31), Ch. Engr., Univ. of Chicago; *for mail*, 7751 S. Marshfield Ave.
JOHNSON, Bradley S. ('09; '13), Engr., W. H. Miner, 667 The Rookery; *for mail*, 1332 Lunt Ave.
JOHNSON, C. Roy (J'34), 2236 Argyle St., Ravenswood Sta.
JOHNSON, Clarence G. ('18), Cons. Engr., Pub. Utilities, 39 S. LaSalle St., Chicago; *for mail*, 417 Sunset Ave., La Grange.
JOHNSON, Emil T. ('24), Ch. M. E., Curtis Lighting Inc., 1119 W. Jackson Blvd.; *for mail*, 6435 N. Talman Ave.
JOHNSON, Geo. A. ('15), Exec. V. P., W. H. Miner, Inc., 209 S. LaSalle St.
JOHNSON, Lloyd M. ('33), Engr., Maint. & Opera. Sanitary Dist. of Chicago, 910 S. Michigan Ave.; *for mail*, 534 Aldine Ave.
JONES, David J. ('18; '30), Mech. Asst., Ill. Cent. System, 135 E. 11th Pl.; *for mail*, 705 E. 88th Pl.
JONES, J. E. ('35; '35), Mech. Designer, Goss Ptg. Press Co., 1535 S. Paulina St., Chicago; *for mail*, 1403 S. 19th Ave, Maywood.
JONES, Robert R. (J'36), Draftsman, Diesel Engines, Tractor Wks., Internatl. Harvester Co.; *for mail*, 6743 S. Artesian Ave.
JURGENS, Emil G. ('27), Gen. Supt., Peters Mchy. Co., 4700 Ravenswood Ave.; *for mail*, 4142 N. Bell Ave.
KANE, Edmund J. ('16), Engr., Moore Speedcrane Co., 39 S. LaSalle St.; *for mail*, 123 N. Waller Ave.
KARSEL, Emil (J'31), Plant Engr., Edw. Katzinger Co., 1949 N. Cicero Ave.; *for mail*, 5627 Cornelia Ave.
KELLOGG, Harry F. ('34), Pres., Cent. Screw Co., 35th St. & Shields Ave.; *for mail*, 5206 University Ave.
KENDRICK, John F. ('26; '35), 1312 N. State St.
KENNEDY, Robt. E. ('21), Tech. Secy., Am. Foundrymen's Assn., 222 W. Adams St.
KENT, Norman W. (J'33), Tech. Colorist, E. I. du Pont de Nemours & Co., 7 S. Dearborn St.
KIMBALL, R. W. ('18), Commonwealth Edison Co., 25th & Quarry Sts.
KISH, Paul L. (J'29), Sales Mgr., Engr. Charge Design, Am. Spring & Wire Specialty Co., 816 N. Spaulding St.
KOENIG, Edw. C. (J'36), Serv. Man, Tool Div., Stanley Wks., 61 W. Kinzie St.; *for mail*, 3635 N. Seeley Ave.
KOERPER, Erhardt C. (J'30), 5647 Blackstone Ave.
KORB, Fred B. ('30; '35), M. E., Gen. Mgmt., Indus. Gas Engrg. Co., Inc., 201 E. Ohio St., Chicago; *for mail*, 5045 W. 24th St., Cicero.
KORFF, Herbert H. (J'36), Sales Engr., Johnson Service Co., 1355 Washington Blvd.; *for mail*, 4526 N. Dover St.
KOTILINEK, John (J'31), Engr., Prater Pulverizer Co., 1829 S. 55th Ave., Chicago; *for mail*, 1315 S. Home Ave., Berwyn.
KOZACKA, J. S. ('32), Assoc. Prof. M. E., Lewis Inst.; *for mail*, 5345 Wolfram St.
KRAUJALIS, Felix S. (J'36), Jr. Design Engr., Hannifin Mfg Co., 821 S. Kolmar Ave.; *for mail*, 2245 W. 22nd St.
KRAUS, Joe, Jr. (J'35), 2522 S. Troy St.
KRAUSE, Robt. (J'36), M. E. Maint., Container Corp. of Am., 404 E. N. Water St.; *for mail*, 5303 Kimbark Ave.
KREHBIEL, Fred A. ('02; '30), Pres., Krehbiel Co., Suite 1454, 222 W. Adams St.
KUEHN, Hugo R. (J'17), 5916 W. Superior St.
KVETON, Norman J. (J'35), 4157 W. 21st Pl.
KYBURZ, Walter Warren ('31; '35), Plant Draftsman, Omaha Packing Co., 2320 S. Halsted St.; *for mail*, 2848 Sheffield Ave.
LANE, Francis H. ('23), Mgr., Engrg. & Constr., Byllesby Engrg. & Mgmt. Corp., 231 S. LaSalle St.
LANE, Wm. T. ('25), Sales Rep., Franklin Ry. Supply Co., 332 S. Michigan Ave.
LANG, Wm. H. ('15), Engr., Charge Erection, Webster Mfg. Co., 1865 N. Kostner Ave.; *for mail*, 7621 S. Union Ave.
LANGSNER, Adolph ('22) M. E., Charge Mfg. Plant, Eugene Dietzgen Co., 954 Fullerton Ave.; *for mail*, 6080 Kirkwood Ave.
LANUS, Paul J. (J'34), Draftsman, Assn. of Am. Railroads, 59 E. Van Buren St.; *for mail*, 160 N. Le Claire Ave.
LARKIN, Frank P. (J'22), Sales Engr., Link-Belt Co., 300 W. Pershing Rd.; *for mail*, 8148 Evans Ave.
LARSON, Emil Lambert ('29), 5468 Woodlawn Ave.
LAWITZ, Leslie L. (J'34), 5244 Drexel Ave.
LEACH, Vernon G. ('23), Ch. Combustion Engr., Fuel Engrg., Peabody Coal Co., 231 S. LaSalle St.
LEBUS, Wm. A. (J'34), 4028 N. Paulina St.
LEIGHTON, A. J. ('32), Rm. 1502, 140 S. Dearborn St., Section 3, Old P. O. Annex.
LENONE, J. M. ('16), Engr., Charge Design, Wilson & Co., Inc., 41st St. & S. Ashland Ave.
LEONARD, Arthur Geo. ('90), Pres., Union Stock Yard & Transit Co., Administration Bldg., Union Stock Yard.
LEWIS, Goodrich Q. ('15; '35), Ch. Engr., W. H. Miner, Inc., Rm. 667, 209 S. LaSalle St.
LILLA, Herbert L. ('19; '21; '26), 5542 W. 64th Pl.
LINK, Chas. T. (J'31), Engr. Asst. to Master Mech., Am. Can Co., 1834 Clybourn Ave.; *for mail*, 1407 Elmdale Ave.
LITHGOW, John ('31; '35), M. E., Charge Testing, Sears Roebuck & Co., Homan & Arthington; *for mail*, 219 N. Lockwood Ave.
LITTLEWOOD, Wm. (J.'22), Ch. Engr., Am. Airlines, Inc., 5036 W. 63d St.
LOCKETT, Kenneth ('04; '07; '13), 4440 Beacon St.
LONG, John E. ('34), Asst. to V. P., Sales, Franklin Ry. Supply Co., 332 S. Michigan Ave.
LUSTIG, Jere David (J'35), Partner & Safety Engr., M. M. Lustig & Son, Rm. 937, 175 W. Jackson Blvd.
LYNAM, Wm. A. (J'36), 4540 Lowell Ave.
MACI, Raymond Jas. (J'35), 2121 Haddon Ave.
MACKLIND, Wm. R. ('14), Apt. 1, 6757 Ogelsby Ave.
MAHER, E. E. ('35), 59 E. Van Buren St.
MAJERCIK, Anthony S. (J'36), 6019 N. Mason Ave.
MALCOLM, Geo. H. ('18), V. P., Otis Elev. Co., 600 W. Jackson Blvd.
MANZ, John W. (J'30), Field Engr., Line Installation Sect., Commonwealth Edison Co., 72 W. Adams St., Chicago; *for mail*, 520 Wapella Ave., Mt. Prospect.
MARK, Walter J. ('26), U. S. Marine Hospital, 4141 Clarendon, Chicago, Ill.; *for mail*, 76 Wilkin St., St. Paul, Minn.
MARSH, Thos. A. ('05; '12), Charge Sales, Iron Fireman Mfg. Co., 660 N. Wabash Ave.; *for mail*, 5625 Kenwood Ave.
MASSEY, Albert G. ('34; '35), Worthington Pump & Mchy. Corp., 400 W. Madison St.
MATCHETT, Jas. C. ('12; '21), V. P., Gen. Mgr., Ill. Engrg. Co., Racine Ave. & 21st St.
MATTESON, Richard J. (J'35), Engr., Research & Devel. Dept., Crane Co., 4100 S. Kedzie Ave.
MAWSON, Robt. ('13), Indus. Engr., Geo. S. May Co., 2600 North Shore Ave.; *for mail*, 4235½ N. Hermitage Ave.
MAY, Edw. A. (J'35), Tracer, Mech. Engrg. Dept., Sanitary Dist. of Chicago, 910 S. Michigan Ave.; *for mail*, 1920 S. Albany Ave.
McALLISTER, Alex. Jos. (J'36), Draftsman, XL Refrig. Co., 1834 W. 59th St.; *for mail*, 611 E. 90th Pl.
McAULEY, Benj. F. ('20), Matl. Handling Engr., Hawthorne Sta., West Elec. Co., Inc.; *for mail*, 3909 Van Buren St.
McCAUSLAND, John W. ('19; '25; '35), Griscom-Russell Co., 814 Monadnock Bldg.; *for mail*, 5807 Dorchester Ave.
McCLINTOCK, J. Phillips (J'35), Indus. Engr., Bauer & Black, Div. of Kendall Co., 2500 S. Dearborn St.; *for mail*, 5457 Everett Ave.
McCORMICK, Milton H. (J'29), 7051 Bennett Ave.
McCOY, Verl E. (J'26), M. E., Wilson Engrg. Corp., 122 S. Michigan Ave.
McEWAN, Thos. S. ('15; '17; '25), Cons. Engr., Stevenson, Jordan & Harrison, 205 W. Wacker Dr.
McGANN, Robt. G. ('23), Pres., McGann Mfg. Co., Inc., 332 S. Michigan Ave.
McGLADREY, L. L. (J'29), Supt. & Engr., Rap-In-Wax Paper Co., 6147 W. 65th St.
McILVAINE, John H. (A'27), Pres., Treas., Gen. Mgr., McIlvaine Burner Corp., 663 W. Washington Blvd.
McKEE, Thos C. ('18), Pres., Midwest Engrg. & Equip. Co., 617 Fulton St.; *for mail*, 4709 Beacon St.
McLAREN, Lewis L. ('15; '24; '35), Plant Engr., Sellers Mfg. Co., 4705 Montrose Ave.; *for mail*, 4029 N. Kedvale Ave.
McLARNEY, Wm. J. (J'30), Instr., M. E., Armour Inst. of Tech., 33d & Federal.
McMAHAN, R. G. (J'33), Power Prover Engr., Cities Serv. Oil Co., 3200 S. Western Ave., Chicago, Ill.; *for mail*, 2120 Meridian St., Anderson, Ind.
McNEILL, Thos. W. ('22), Cons. Engr., T. W. McNeill Engrg. Equip. Co., 4057 W. Van Buren St.; *for mail*, 951 Lorel Ave.
McPARTLAND, Michael B. ('16), Gen. Supt., Motive Power, Chicago, Rock Island & Pac. Ry., LaSalle St. Sta.
MEDBERY, Edward W. (J'32), Indus. Engr., Marshall Field & Co., Merchandise Mart, Chicago; *for mail*, 1624 Walnut St., Waukegan.
MEIER, Fred ('22), Supt., Sherwin-Williams Co., 115th & Cottage Grove; *for mail*, 8035 Blackstone Ave.
MEISSNER, John F. ('30), Dist. Mgr., Robins Conveying Belt Co., 37 W. Van Buren St., Chicago; *for mail*, 423 S. Madison Ave., La Grange.
MEKLER, L. A. ('30), Combustion Engr., Universal Oil Products Co., Rm. 2120, 310 S. Michigan Ave.
MERRILL, J. J. ('11), M. E., Corn Products Refining Co., Rm. 700, 333 N. Michigan Ave.
MESSINGER, Chas. R. (A'18), Pres., Oliver Farm Equip. Co., Rm. 2200, 400 W. Madison St.
METCALF, Irving R. ('30; '35), Ch. Engr., Latham Mchy. Co., Chicago; *for mail*, 403—6th St., S., St. Charles.
METCALF, Stanley C. ('35), Process Designing Engr., Universal Oil Products Co., 310 S. Michigan Ave., Chicago; *for mail*, 819 S. 9th Ave., Maywood.
MEYERCORD, Geo. R., Jr. (J'30), V. P., Charge Sales, Haskelite Mfg. Corp., 208 W. Washington St.
MICHAEL, Loren P. ('21), Ch. M. E., Chicago & Northwest. Ry. Chicago; *for mail*, 112 Marion St., Elmhurst.
MICHEL, John R. ('30; '35), Boiler Rm. Engr., Commonwealth Edison Co., Fisk St. Sta., 22nd & Fisk Sts.
MIKESKA, P. Lawrence (J'28), 501 N. Central Ave.
MILLER, John M. (J'28), Pilot, United Air Lines Transport Corp., Municipal Airport, Chicago, Ill.; *for mail*, 35 Columbia Ave., Cranford, N. J.
MINKEMA, Wm. H. ('18; '25; '35), Universal Oil Products Co., 310 S. Michigan Ave.; *for mail*, 10716 S. State St.
MITCHELL, W. G. (J'33), Buyer of Power Tools, Sears Roebuck & Co., Homan Ave. & Arlington St., Chicago; *for mail*, 604½ N. Austin Blvd., Oak Park.
MOLLER, Jos. A. ('24; '30; '34), Asst. Ch. Lub. Engr., Head Mech. Research Lab., Pure Oil Co., 35 E. Wacker Dr.
MONRO, Donald A. ('24; '31; '35), 7130 Cyril Pkwy.
MONROE, Wm. S. ('96; '01), Pres., Sargent & Lundy, Inc., 140 S. Dearborn St.
MOREY, Albert A. (A.'31), Marsh & McLennan, 164 W. Jackson Blvd.
MORGAN, Harold H. ('22), Dept. Mgr., Robt. W. Hunt Co., 2200 Insurance Exchange Bldg.
MORGAN, Verner D. (J'35), M. E. Draftsman, Graham, Anderson, Probst & White, Architects, 1417 Railway Exchange Bldg.; *for mail*, Morlond Hotel, 4946 Sheridan Rd.
MORRIS, Richard H. ('36), *Student Award*, '21; Assoc. Editor, Power Plant Engineering, 53 W. Jackson Blvd.
MORRISON, Edgar G. (J'35), Layout Engr., Goss Ptg. Press Co., 1535 S. Paulina St.
MORSE, Chas. H. ('97; '04), Exec., Fairbanks, Morse & Co., 900 S. Wabash Ave.
MORSE, Louis S., Jr. (J'33), Air Conditioning Sales Engr., Westerlin & Campbell Co., 1113-23 Cornelia Ave.

MORSE, Robt. H. (A'22), Pres., Gen. Mgr., Fairbanks, Morse & Co., 900 S. Wabash Ave.
MOWAT, J. Fred ('16), Engr., Chicago Dist., Carnegie-Ill. Steel Corp., 208 S. LaSalle St.; *for mail*, 10629 Longwood Dr.
MUELLER, Wm. C. ('28), Mfg. Engr., Hawthorne Stà., West. Elec. Co., Inc.; *for mail*, 2225 Giddings St.
MULLER, Julius ('27; '28; '35), 10743 S. Wood St.
MUMMERT, Harold B. (J'31), Jr. Engr., Voltage Regulation, Commonwealth Edison Co., 72 W. Adams St., Chicago, Ill.; *for mail*, 353 Chicago St., Valparaiso, Ind.
MUNN, Harvey T. ('21; '29), Hyd. Engr., Natl. Bd. Fire Underwriters, Rm. 953, 222 W. Adams St.
MURPHY, Edw. T. ('05; '17), 180 N. Michigan Ave.
NACHMAN, Henry L. ('21), Prof. Thermodynamics, Armour Inst. of Tech., 3300 Federal St.
NEAL, R. S. ('22; '35), Lub. Engr., Texas Co., 332 S. Michigan Ave., Chicago; *for mail*, 608 Park Dr., Joliet.
NEALE, John A. ('25), Ch. Engr., Chicago Bd. of Underwriters, Rm. 2158, 175 W. Jackson Blvd.
NEILER, Samuel G. ('07), Senior Partner, Neiler, Rich & Co., 431 S. Dearborn St.
NEUMANN, Arthur E. ('29; AM'35), M. E., I. H. Wilsey, 512 Wrigley Bldg.; *for mail*, 7919 S. Ridgeland Ave.
NICHOLS, Orlando ('26; '35), Loco. Engr., Chicago & Northwest. Ry.; *for mail*, 732 N. Drake Ave.
NOLTE, Chas. B. ('17), Pres., Crane Co., 836 S. Michigan Ave.
NORTHAM, Carleton D. (J'24), Asst. Supt. Steam Power, Wisconsin Steel Wks., Internatl. Harvester Co., 2701 E. 106th St.; *for mail*, 2242 W. 109th St.
NORTHCLIFFE, Lee C. (J'21), Flash Drying & Incineration Div., Raymond Bros.; *for mail*, 2171 N. Meade Ave.
NUGENT, Corliss D. ('29), V. P., Secy., Wm. W. Nugent & Co., Inc., 410 N. Hermitage Ave., Chicago; *for mail*, 804 Elmwood Ave., Wilmette.
NULSEN, John C. ('28), Gen. Mgr., West. Fdy. Co., 36th & Kedzie Ave., Chicago; *for mail*, 65 Ackenside Rd., Riverside.
NYGAARD, Kenneth C. (J'31), Engr., Maint. Dept., Carnegie-Ill. Steel Corp., 3426 E. 89th St.; *for mail*, 3039 E. 91st St.
OBERGFELL, H. F. ('34), Engr., Charge Design, Associated Elec. Labs., Inc., 1033 W. Van Buren St.
O'BRIEN, John E. ('15), 200 E. Delaware Pl.
OGDEN, W. B. ('30), Asst. Dir. of Purchases, Libby, McNeill & Libby, Union Stock Yards; *for mail*, 6204 S. Sacramento Ave.
OKNER, Bernard S. ('34), Ch. Engr., Ahlberg Bearing Co., 317 E. 29th St.
O'LEARY, Paul C. (J'34), Natural Gas Pipeline Co., 20 N. Wacker Dr.
OLSON, Carl G. ('18), V. P., Ch. Engr., Ill. Tool Wks., 2501 N. Keeler Ave.
OLSON, Robt. A. (J'36), 6417 Newgard Ave.
OLT, Richard G. (J'36), c/o International Filter Co., 59 E. Van Buren St.
O'MARA, R. F. (J'28), Engr., Raymond Bros. Impact Pulverizer Co., 1319 N. Branch St.
ONSRUD, R. F. ('35), Secy. Sales Prod., Onsrud Mch. Wks., Inc., 3900 Palmer St.
ORR, Fred B. ('21), Asst. to V. P., Ill. Maint. Co., Rm. 1136, 72 W. Adams St.
OSTERMANN, Rudolph M. ('13), V. P., Superheater Co., 122 S. Michigan Ave.
OTTE, Karl H. P. (J'26), M. E., West. Elec. Co., Inc.; *for mail*, 1320 Rosedale Ave.
PAGE, Chas. Bernard ('31), Pres., Steam & Combustion Co., Inc., 1559 Sheffield Ave.
PARKE, Peter ('14), Ch. Engr., Design & Constr., Pullman Co., 79 E. Adams St.; *for mail*, 1725 E. 53rd St.
PARKS, Addison M. (J'33), Traveling M. E., Gen. Engrg. Div., Armour & Co., Union Stock Yards, Chicago, Ill.; *for mail*, 1230 S. 1st St., Louisville, Ky.
PARSONS, Harry N. ('12; '19; '34), Ch. Engr., Ball & Roller Bearing Div., Internatl. Harvester Co., 1015 W. 120th St.
PARSONS, Winchell M. (J'36), Jr. Angr., Ralph M. Parsons Co., 310 S. Michigan Ave.
PATTEN, E. L. O. (J'15), Engr., Design & Prod., Edison Gen. Elec. Appliance Co., 5600 W. Taylor St., Chicago; *for mail*, Carleton Hotel, Oak Park.
PATTERSON, David W. ('23), Engr., Universal Oil Products Co., 310 S. Michigan Ave.
PAUL, John S. ('18; '29), M. E., Sears, Roebuck & Co., Chicago; *for mail*, 400 N. Ashland Ave., La Grange.
PAVEY, Wm. J. (J'36), Engr., Mfg. Dept., Economy Engrg. Co., 2653 W. Van Buren St., Chicago; *for mail*, 845 Lincoln Ave., Winnetka.
PAYNE, Frank E. ('22), Pres., Crane Packing Co., 1800 Cuyler Ave.
PEARL, Jas. W. ('20), 1140 E. 44th St.
PEI, Ching Pong ('26; '28; '32), Research Engr., Loco. Firebox Co., 310 S. Michigan Ave.
PELLER, Leonard (J'33), Engr., Devel. & Sales, Perfection Gear Co., Harvey; *for mail*, 1359 N. Wells St., Chicago.
PERRY, Edwin Hazard ('26), Ch. Engr., Sears, Roebuck & Co., Chicago; *for mail*, 388 Holly Ave., Elmhurst.
PFAUTSCH, R. V. (J'30), Engr., Devel. Wk., Ilg Elec. Vent. Co., 2850 N. Crawford Ave.; *for mail*, 2340 N. Kedvale Ave.
PFISTERER, Geo. E. ('13; '21; '21), Pres., Mgmt. & Exposition, Inc., 308 W. Washington St.
PHILLIPS, Wm. Henry ('24; '27), Power Plant Specialist, Worthington Pump & Mch. Corp., 400 W. Madison St., Chicago; *for mail*, 143 N. Lombard Ave., Oak Park.
PHINNEY, Robt. E. (J'30), Supt. Power, Coated Bd. Div., Container Corp. of Am., 404 E. N. Water St.
PIERCE, Jos. D. (J'36), Student Training Course, Crane Co., 836 Michigan Ave.; *for mail*, 5052 Ellis Ave.
PIERSON, Joe W. ('30), Boiler Rm. Engr., Commonwealth Edison Co., 22nd & Fisk St.
PIETERS, Ivon S. ('22; '25; '35), V. P., Plibrico Jointless Firebrick Co., 1840 Kingsbury St.
PINDRAS, Raymond (J'36), Engr., Charge Testing, Economy Pumping & Mchy. Co., 3431 W. 48th Pl.; *for mail*, 3403 N. Springfield Ave.
PIWINSKI, Edw. J. (J'35), Crane Co.; *for mail*, 1057 N. Leavitt St.
PLONSKER, Maurice J. ('17; '22; '35), V. P., Charge Engrg., Plonsker Engrg. Co., 32 S. Jefferson St.
POPE, Saml. A. (J'15), Contr. Engr., Wm. A. Pope, 26 N. Jefferson St.
POTTER, Wm. H. ('28), Scovell, Wellington & Co., 105 W. Adams St.
POWERS, M. E. ('31), Ptg. Engr., Pettengill Inc., 1700 Prairie Ave.; *for mail*, 4727 Malden Ave.
PRATT, Chas. A. ('27), V. P., Goodman Mfg. Co., 4834 S. Halsted St.
PRATT, J. H. (J'18), V. P., Charge Mfg. & Engrg., Liquid Carbonic Co., 3100 S. Kedzie Ave., Chicago; *for mail*, 937 Fair Oaks Ave., Oak Park.
PROFFITT, Russell P. ('30), Dist. Mgr., Timken Roller Bearing Co., 2534 S. Michigan Blvd.
PRUSSING, Rudolph E. ('15), V. P. & Gen. Sales Mgr., Whiting Corp., Harvey; *home address*, 20 Cedar St., Chicago.
PURCELL, John ('33), Asst. to V. P., Charge Mech. Dept., Atchison, Topeka & Santa Fe R. R., 80 E. Jackson St.
PUTNAM, Jos. W., Jr. (J'28), Mgr., Baffle Wall Dept., Plibrico Jointless Firebrick Co., 1800 Kingsbury St.
RAGLAND, Wm. Max (J'33), Maint. Clerk, Asst. to Maint. Supvr., Am. Airlines, Inc., 4848 W. 63rd St., Chicago; *for mail*, 1316 Wabash Ave., Mattoon.
RAMBOLT, Chas. L. (J'30), Asst. Engr., West. Elec. Co., Inc., Hawthorne; *for mail*, 616 Belden Ave., Chicago.
RANSTEAD, Norman H. ('27), Designing Engr., Universal Oil Products Co., 310 S. Michigan Ave.; *for mail*, 7615 Sheridan Rd.
RAPP, A. G. J. ('20), Rapp & Hollins, 7001 N. Clark St., Chicago; *for mail*, 540 Michigan Ave., Evanston.
RASMUSSEN, Frank ('30), Sales Engr., Link-Belt Co., 910 S. Michigan Ave., Chicago; *for mail*, 735 Judson Ave., Evanston.
RATCLIFF, Vern H. (J'34), Bldg. Supt., Ch. Engr., Englewood Y. M. C. A., 6545 S. Union Ave.
REDIN, Eric G. (J'28), Penolite Corp., 231 S. LaSalle St., Chicago; *for mail*, Crystal Lake Ave., Crystal Lake.
REDMAN, David F. (J'35), Student Engr., W. Pullman Wks., Internatl. Harvester Co.; *for mail*, 6840 Perry Ave.
REID, H. P. ('35), Spec. Engr., Universal Atlas Cement Co., 208 S. LaSalle St.
REILEY, Robt. C. (J'36), Student, Crane Co., 836 S. Michigan Ave.; *for mail*, 5052 Ellis Ave.
REIMULLER, Caryl Ludwig (J'34), Designing Engr., B. F. Gump Co., 431 S. Clinton St.; *for mail*, 6647 N. Greenview Ave.
REITZEL, Holger B. (J'36), Cost Clerk, R. B. Hayward Co., 1714 Sheffield Ave.; *for mail*, 5317 Berteau Ave.
RICE, Arthur H. (J'36), 7122 Normal Blvd.
RICE, Arthur L. ('95; '02; F'36), Vice-President, '22; Editor, Power Plant Engineering, Tech. Publ. Co., 53 W. Jackson Blvd.
RICE, Richard A. (J'34), Serviceman, Am. Can Co., 14th & Sheridan Rd., N. Chicago.
RICHARDSON, L. A., Jr. (J'33), Suprv., Air Conditioning, Chicago, Rock Island & Pac. Ry., LaSalle St. Sta.; *for mail*, 2662 E. 73d St.
RIETZ, Elmer W. ('32), Gen. Sales Mgr., Powers Regulator Co., 2720 Greenview Ave., Chicago; *for mail*, 2250 S. Sheridan Rd., Highland Park.
RIOPELLE, Constantine P. ('28), Ch. Engr., Charge Bldg. Plant, Willoughby Co., 8 S. Michigan Ave.; *for mail*, P. O. Box 314.
RIPLEY, C. T. ('29), Ch. M. E., Atchison, Topeka & Santa Fe Ry., 80 E. Jackson Blvd.
RIPLEY, R. L. ('31), Salesman, Babcock & Wilcox Co., 140 S. Dearborn St.
RITTER, Kurt (J'29), M. E., Teleweld, Inc., 525 W. 76th St.
RITTER, Walter T. ('24; '32), M. E., Chicago Carton Co., 4200 S. Crawford Ave., Chicago; *for mail*, 616 Lathrop Ave., River Forest.
ROBERT, John ('20; '26), Plant Engr., Barrett Co., 2800 S. Sacramento Ave.
ROBERTON, John, Jr. (J'33), M. E. Charge Maint., Miller & Hart, 46th & Packers.
ROBERTS, Chapin ('14; '21), Constr. Dept., Sears, Roebuck & Co., Chicago; *for mail*, 317 N. Euclid Ave., Oak Park.
ROBERTS, John T. (J'36), Student Engr., Crane Co., 4100 S. Kedzie; *for mail*, 5514 S. Spaulding Ave.
ROBINSON, Ted. H. (J'33), Asst. Engr., Gas Dept., Carbide & Carbon Chem. Corp., Whiting, Ind.; *for mail*, 7235 Philips Ave., Chicago, Ill.
ROESCH, Daniel ('25), Prof. Automotive Engrg., Armour Inst. of Tech., 3300 Federal St.; *for mail*, 2136 W. 108th Pl.
ROESCH, Frank P. ('19), V. P., Charge Sales, Stand. Stoker Co., Inc., 332 S. Michigan Ave.
ROOT, Jos. J., Jr. ('14), Asst. to V. P., Union Tank Car Co., 228 N. LaSalle St.
RORABECK, Claude (A'17), Pres., Link-Track Engrg. Co., Rm. 540, 410 N. Michigan Ave.
ROSENBERG, L. W. (J'35), Sales Engrg. Student, Texas Co., 332 S. Michigan; *for mail*, 4862 Blackstone Ave.
ROSS, Harold E. (J'27), Engrg. Div., Armour & Co., Union Stock Yards; *for mail*, 8314 East End Ave.
ROWLEY, Edw. R. (J'30), M. E., Natl. Lead Co., 900 W. 18th St.; *for mail*, 3752 Ward St.
RULE, Perrin ('18), Supt., Youngstown Sheet & Tube Co., 94th St. & Kreiter Ave.
RUTHERFORD, Marvin H. (J'29), Asst. Engr., Chicago Transformer Corp., 2626 W. Washington Blvd.
SANDO, Will J. ('99; F'36), Manager, '08-'11; Vice-President, '23-'25; Cons. Engr., 2350 Lincoln Park, West.
SARACINO, Frank E. (J'31), Operating Engr., Lincoln-Boyle Ice Co., 4628 Greenview Ave.; *for mail*, 7751 N. Hermitage Ave.
SARGENT, Ralph ('28), V. P., Sargent & Lundy, Inc., 140 S. Dearborn St.
SAYERS, Wm. W. ('01; '06), Ch. Engr., Link-Belt Co., 307 N. Michigan Ave.
SCHALLER, W. F. ('21), V. P., Marquette Elec. Switchboard Co., 311 N. Desplaines St.
SCHMIDT, John Henry (J'30), 7748 S. Kingston Ave.
SCHMITT, Bernard A. ('36), 205 W. Wacker Dr.
SCHNITZER, Sidney (J'35), Asst. to Ch. Engr., Research & Testing, Askania Regulator Co., 1603 S. Michigan Ave.; *for mail*, 2116 N. Spaulding Ave.
SCHOENFELD, David M. ('26; '35), Engr., Combustion Engrg. Co., Inc., 1930 Bankers Bldg.
SCHOLES, Daniel R. ('18), V. P., Aermotor Co., 2500 Roosevelt Rd.
SCHROEDER, Bernhard ('35), V. P. & Ch. Engr., Sargent & Lundy, Inc., Rm. 1600, 140 S. Dearborn St.
SCHROEDER, John F. (J'31), Plant Engr., Bird & Son, Inc., 1472 W. 76th St.; *for mail*, 1627 W. 106th St.
SCHULTZ, Alfred Wm. (J'31), Ch. Draftsman, Clearing Mch. Corp., 6499 W. 65th, Chicago; *for mail*, Apt. A-3, 116½ S. Maple, Oak Park.
SCHWANBECK, Harold A. (J'33), Student, Rotary Press Rm., R. R. Donnelley & Sons Co., 350 E. 22nd St.; *for mail*, 2523 N. Lockwood Ave.
SCHWEISTHAL, Fred G. ('21; '35), Engr., Charge Research Div., Stewart-Warner Corp., 1826 Diversey Pkwy.; *for mail*, 6602 N. Artesian Ave.
SEELIG, Lester ('19; '25; '30), M. E., Charge Engrg. & Shops, Museum of Sci. & Indus., Jackson Park; *for mail*, 725 Irving Park Blvd.
SELIM, John D. (J'33), M. E., Internatl. Harvester Co., 26th & 31st Blvd.; *for mail*, 3210 Arthington St.
SHEARER, Thos. J. ('24; '35), Sales Engr. & Mid-West Rep., Kennedy-Van Saun Mfg. & Engrg. Corp., 100 W. Monroe St.
SHERMAN, Delmar C. ('22; '27), Sherman & Reilly, Inc., 1301 Peoples Gas Bldg.
SHERMAN, Victor L. ('35), Acting Head, Dept. M. E., Lewis Inst., Madison & Damen Aves.
SHERWOOD, Mather W. ('09), 1901 Farwell Ave.
SIR, Walter W. ('30), M. M., Commonwealth Edison Co., 3501 S. Pulaski Rd.
SKOG, Ludwig ('35), Ch. M. E., Sargent & Lundy, Inc., 140 S. Dearborn St.
SMITH, A. E. ('16), V. P., Union Tank Car Co., 229 N. LaSalle St.
SMITH, H. Collier, Jr. (J'31), Pres., Quickwork Co., 900 N. Spaulding Ave.

SMITH, Thos. J. (J'30), Sales Engr., Powers Regulator Co., 2720 Greenview Ave.
SMITH, Walter ('30), Mgr. R. R. Div., Vanadium Corp. of Am., 961—1st Natl. Bank Bldg.; *for mail*, 8042 Merrill Ave.
SNASHALL, Newton W. (J'36), 3739 Stella Blvd.
SNEDDEN, Wm. T. ('32), 826 Edgecomb Pl.
SNIDER, Lewis A. ('18), Pres., L. A. Snider Engrg. Serv., Inc., 605 N. Michigan Ave.
SNOWDEN, H. J. ('20), Stand. Steel Wks. Co., 627 Railway Exchange.
SPIRO, Irving John (J'36), Draftsman, Tech. Clerk, Internatl. Harvester, 2626 W. 31st Blvd.; *for mail*, 3855 Van Buren.
SPITZGLASS, Albert F. ('26; '35), V. P., Charge Engrg., Republic Flow Meters Co., 2240 Diversey Pkwy.
STANGELAND, Ole I. (J'36), Design Engr., Foote Bros. Gear & Mch. Corp., 5301 S. Western Blvd.; *for mail*, 1603 N. Richmond St.
STARK, Julian E. ('17; '20), Mgr., Catalogue Dept., Crane Co., 836 S. Michigan Ave.
STECZYNSKI, Myron E. ('24; '29), Ch. Engr., Knight Soda Fountain Co.; *for mail*, 5144 Berteau Ave.
STEFFA, Homer I. ('21), Ch. M. E., Sanitary Dist. of Chicago, 910 S. Michigan Ave.; *for mail*, 5507 Huron St.
STEUR, Wm. R. (J'35), Designing Draftsman, Sargent & Lundy, 140 S. Dearborn St., Chicago; *for mail*, 1709 Chicago Ave., Evanston.
STEVENS, Burt D. ('12), 1st. V. P., Charge Engrg., Miehle Ptg. Press & Mfg. Co., 2011 Hastings St.
STEVENSON, Walter N. ('21), Partner, S. & S. Mch. Wks., 4541 W. Lake St.
STONE, Jos. L. (J'33), Draftsman, Loco. Wk., Ill. Cent. System, Rm. 901, Central Sta.
STRUTZ, Clarence R. (J'36), M. E., Oxweld R. R. Serv. Co., 230 N. Michigan Ave.; *for mail*, 2726 W. 24th St.
SULLIVAN, John F., Jr. ('24; '34), Supt., Struc. & Mech. Div., Commonwealth Edison Co., 72 W. Adams St.
SULLIVAN, Raymond H. ('20), Ingersoll Steel & Disc Div., Borg-Warner Corp., 1030 W. 120th St.
SUROWIEC, R. J. (J'32), 13037 Houston Ave.
SVEC, Wm. F. ('23; '35), 5934 W. Lake St.
SWANSON, Norman W. (J'36), 7549 N. Barton Ave.
SYKES, Wilfred ('22), Asst. to Pres., Inland Steel Co., 38 S. Dearborn St.
TAYLOR, J. Hall ('12), Pres., Taylor Forge & Pipe Wks., Box 485.
TAYLOR, John O. ('21), Cons. Engr., Kroehler Mfg. Co., 666 Lake Shore Dr.
TELLIS, V. G. ('26), Asst. Engr., Valuation Dept., Chicago, Rock Island & Pac. Ry. Co., LaSalle St.; *for mail*, 1345 E. 50th St.
TERRY, Carlyle Marshall ('18; '25; '31), Lieut., E-F U. S. N. R., U. S. Naval Armory, Foot of Randolph St.
TEST, Ellis W. ('19), Asst. to Pres., Pullman-Stand. Car Mfg. Co., 79 E. Adams St., Chicago; *for mail*, 134 E. 4th St., Hinsdale.
THORP, Geo. G. ('92; '04), Pres., Ill. Steel Co., Rm. 1624, 208 S. LaSalle St.
TIFFT, Wm. C. (J'25), Asst. Ch. Engr., Chas. F. Elmes Engrg. Wks., Morgan & Fulton Sts., Chicago, Ill.; *for mail*, 53 Swan Ave., Seymour, Conn.
TINDALL, Edwin L. (J'29), Combustion Engr., South Wks., Ill. Steel Co., 89th & Strand Sts.; *for mail*, 2208 E. 70th St.
TOLMAN, Edgar Bronson, Jr. ('29), Pres., United Conveyor Corp., Old Colony Bldg., 37 W. Van Buren St.; *for mail*, 5333 University Ave.
TOWNSEND, John S. ('27), Maint. Dept., Carnegie-Ill. Steel Co., 3426 E. 89th St.; *for mail*, 10527 Hale Ave.
TOZER, Sydney J. (J'33), Ch. Engr., Power, Heat & Light, Am. Can Co., 6005 S. Western Ave.; *for mail*, 6723 S. Maplewood Ave.
TRANZEN, Karl ('34; '35), Oper. Engr., Armour & Co., Union Stock Yards; *for mail*, 1211 Addison St.
TRAVIS, Leonard J. (J'24; '35), Asst. Gen. Supt., Charge Prod. & Engrg., Natl. Lead Co., 900 W. 18th St.
TREFF, Alfred ('31; '35), Designing Engr., McDonald Plant, Continental Can Co., 7600 S. Racine Ave.; *for mail*, 7833 Bishop St.
TRUE, Chas. H. ('13), Raymond Bros. Impact Pulverizer Co., 1319 N. Branch St.
TURNER, Ralph E. ('15; '24), Managing Editor, Power Plant Engineering, Tech. Publ. Co., 53 W. Jackson Blvd., Chicago; *for mail*, 4313 Central Ave., Western Springs.
TURZICKY, Francis C. ('27), Engr., Charge Design, Ill. Malleable Iron Co., 1801 Diversey Pkwy.; *for mail*, 652 Aldine Ave.
UNGER, John S. ('86), 640 Grace St.
VALUCH, John Thos. (J'33), M. E., Container Corp. of Am., 1301 W. 35th St.; *for mail*, 5109 N. Tripp Ave.
VAN ZANDT, Paul C. ('00; '07; '09), V. P., Charge Opera. & Engrg., Universal Atlas Cement Co., 208 S. LaSalle St.
VECK, Milton Frank (J'27), Mech. Indus. Engr., 3817 Eddy St.
VOCELKA, John (J'29), Engr., Charge Design, Wm. W. Nugent & Co., 410 N. Hermitage Ave.
VOKAC, Chas. W. (J'34), Layout Inspc., McCormick Wks. International Harvester Co., Oakley & Blue Island Aves., Chicago; *for mail*, 4818 W. 23rd Pl., Cicero.
VOKOUN, Otto H. ('28; A-M'34), Engr., Planning Dept., Swift & Co., Union Stock Yards; *for mail*, 3140 W. 59th St.
VOSS, Gustav Paul (J'36), Mch. Designer, Mojonnier Bros. Co., 4601 W. Ohio St.; *for mail*, 841 N. Long Ave.
WACHS, Chas. L. ('18), Pres., E. H. Wachs Co., 1525 Dayton St.
WACHS, Theo. ('11; '18; '19), Secy., Charge Design, E. H. Wachs Co., 1525 Dayton St.
WAHL, H. R. ('15), Sta. Design Engr., Commonwealth Edison Co., 72 W. Adams St.; *for mail*, c/o W. Julian, 7444 Kingston Ave.
WALKER, Harold F. (J'28), Factory Planning Engr., West. Elec. Co., Inc., Chicago; *for mail*, 1929 Wesley Ave., Berwyn.
WALLACE, Chas. H. ('29; '35), Sales Engr., Norma-Hoffmann Bearings Corp., 310 S. Michigan Ave.
WALLACE, L. W. ('12), Dir., Equip. Research, Assn. of Am. Railroads, 59 E. Van Buren St.
WALLACE, Robt. A. ('34; '35), Plant Indus. Engr., Charge Indus. Engrg., S. Wks., Carnegie-Ill. Steel Corp., E. 89th St.
WALTERS, W. T. ('15; '17; '35), Htg. & Vent. Engr., Ill. Engrg. Co., 21st & Racine Aves.; *for mail* 7965 Phillips Ave.
WANDREY, Erwin (J'33), 5936 N. Campbell Ave.
WARD, Jas. H., Jr. (J'29), Mill Foreman, Struc. Products Prod., S. Wks., Carnegie-Ill. Steel Corp., S. Chicago; *for mail*, 7083 Chappel Ave., Chicago.
WARD, Wm. Edw. (J'32), Devel. Engr., Charge New Design, Clearing Mch. Corp., 6499 W. 65th St., Chicago; *for mail*, 122 S. Maple Ave., Oak Park.
WEBB, Edwin W. ('24), Ch. Engr., Stand. Car Truck Co., 1322 McCormick Bldg.
WEINSHANK, Theo. ('06), 3307 Belden Ave.
WELCH, Leon C. ('13), Asst. Gen. Mgr., Stand. Oil Co. of Ind., 910 S. Michigan Ave.
WELLS, Earle Wm. (J'32), Engr., Charge Research, Control & Design, Container Corp. of Am., 905 N. May St.; *for mail*, 1857 N. Damen Ave.
WELLS, Willard H. (J'36), 4735 Kelso Ave.
WENZEL, Alfred C. (J'27), Devel. Engr., Republic Flow Meters Co., 2240 Diversey Pkwy.
WEYKER, Wm. J. ('30), Ch. Engr., Commonwealth Edison Co., 3501 S. Pulaski Rd.
WHITE, Dan I. (J'34), Process Serv. Oper., Linde Air Products Co., 230 N. Michigan Ave.; *for mail*, 2339 Cleveland St.
WHITE, William Braid ('23; '30), Dir. Acoustic Research, Am. Steel & Wire Co., 208 S. LaSalle St.; *for mail*, 5149 Agatite Ave.
WHITESIDE, Saml. P. ('16), Test Engr., Swift & Co., Union Stock Yards, Chicago; *for mail*, 856 Hinman Ave., Evanston.
WHITING, Edw. M. ('27; '35), V. P., Pheoll Mfg. Co., 5700 Roosevelt Rd.
WHITING, John G. ('29; '35), Indus. Economist, Suite 1800, 180 N. Michigan Ave.
WHITON, Herbert S. ('15), Ch. M. E., Byllesby Engrg. & Mgmt. Corp., 231 S. LaSalle St.
WICKLATZ, Edw. G. (J'36), Alemite, Dept. Engrg. & Design, Stewart-Warner-Alemite, 1828 Diversey Pkwy.; *for mail*, 2121 Thomas St.
WIDDICOMBE, R. A. ('98; '06), 1120 Lake Shore Dr.
WIELAND, G. E. (J'32), 5254 N. Kimball Ave.
WILCOX, Clyde E. ('34; '35), Equip. Engr., Automatic Elec. Co., 1033 W. Van Buren St.
WILEY, F. H. (J'30), 8612 S. Saugamon St.
WILLIAMS, Geo. Leslie ('17; '24), M. E., Armour & Co., Union Stock Yards, Chicago; *for mail*, 921 Bell Ave., La Grange.
WILLIAMS, H. G. ('35), Engr., Raw Material Devel., Hawthorne Sta., Western Elec. Co., Inc., Chicago; *for mail*, 230 Washington Blvd., Oak Park.
WILLIAMSON, Wm. R. ('21; '26), Pres., W. F. Williamson Adv. Serv., Rm. 1115, 919 N. Michigan Ave.
WILSON, Alex H. ('18; '35), Ch. Engr., Thomas Hoist Co., 20 S. Hoyne Ave., Chicago; *for mail*, 1118 S. Home Ave., Oak Park.
WILSON, John E. ('20), Mgr., Constr. Dept., Swift & Co., Union Stock Yards; *for mail*, 6210 Ingleside Ave.
WILSON, Jos. Bancroft ('17; '18), Power Engr., Westinghouse Elec. & Mfg. Co., 20 N. Wacker Dr.; *for mail*, 9737 Vanderpoel Ave.
WILSON, Thos. ('17), Mgr. Chicago Office, Engrg. Societies Employment Service, 211 W. Wacker Dr.; *for mail*, 6132 Greenwood Ave.
WINBOLT, L. W. (J'33), Engine Testing Lab., Tractor Wks., Internatl. Harvester Co., Chicago; *for mail*, 614 N. Cross St., Wheaton.
WINTERROWD, W. H. ('07; '16), V. P., Franklin Ry. Supply Co., 332 S. Michigan Ave.
WITT, J. C. ('22), Chem. Engr. & Dir. of Res., Universal Atlas Cement Co., 208 S. LaSalle St.; *for mail*, 5834 Stony Island Ave.
WOJTASIK, Edmund M. (J'34), 2644 Potomac Ave.
WOLF, Julius ('20; '25; '35), Coal Sales Mgr., Material Serv. Corp., 33 N. LaSalle St.
WOLFE, Thos. F. ('26), Research Engr., Cast Iron Pipe Research Assn., 122 S. Michigan Ave.
WOOD, Wm. G. (J'34), 143 E. Ontario St.
WOODWARD, Arthur H. ('13), Pres., Internatl. Register Co., 15 S. Throop St.
WOODWARD, E. L. (A'20), West. Mech. Editor, Railway Age, Simmons-Boardman Publ. Co., 105 W. Adams St.
WORTHINGTON, Emory W. (J'35), Engr., Mch. Designer, Goss Ptg. Press Co., 1535 S. Paulina St.; *for mail*, 2136 Lincoln Park, W.
WRIGHT, Donald C. ('17; '19), Asst. Factory Mgr., Sears, Roebuck & Co., Arthington St. & Homan Ave., Chicago; *for mail*, 3425 Wenonah Ave., Berwyn.
YOUNG, Wm. V. (A'17), V. P., Am. Appraisal Co., 38 S. Dearborn St.
YOUNGLOVE, E. H. (A'27), Gen. Staff Mgr., Johns Manville Sales Corp., 230 N. Michigan Ave.
ZAHLEN, John Valfrid ('25), 1938 Otto St.
ZEMKE, Arthur W. (J'22), Exper. Engrg. Dept., Internatl. Harvester Co.; *for mail*, 3939 Federal St.
ZEPERNICK, Wm. ('25; '35), Otis Elev. Co.
ZIMMERMAN, Chas. ('26; '35), Supt., Raymond Lead Wks., Natl. Lead Co., 900 W. 18th St.; *for mail*, 1020 S. Mansfield Ave.
ZUCROW, Maurice J. ('32), Research & Devel. Engr., Republic Flow Meters Co., 2240 Diversey Blvd.; *for mail*, 6215 N. Claremont Ave.
ZUZULY, Walter S. (J'32), Car Designer, Pullman Stand. Car & Mfg. Corp., 11001 Cottage Grove Ave.; *for mail*, 10714 Langley Ave.

CHICAGO HEIGHTS, Chicago Section

BOYAR, S. L. (J'34), V. P., Plumbing & Htg., Sears, Roebuck & Co., 11417 S. Michigan Ave., Chicago; *for mail*, 1515 Schilling Ave., Chicago Heights.
LISCIANI, Constantine (J'36), Engr. Draftsman, Protectoseal Co. of Am., 1920 S. Western Ave., Chicago; *for mail*, R. 2, Box 51 C, Chicago Heights.
PITTS, Howard H. (J'34), Engr., Wardway Paint Wks., Montgomery Ward & Co., Chicago Heights; *for mail*, 1110 N. Mason Ave., Chicago.
PRICE, F. C. ('32; '35), M. E., Charge Design, Victor Chem. Wks., 11th & Arnold Sts.; *for mail*, 219 W. 13th St.
SHEEHAN, Edw. W. (J'33), Engr., Ry. Steel Spring Div., Am. Loco. Co., Box 59; *for mail*, 1419 Schilling Ave.

CICERO, Chicago Section

CIAPINSKI, Chester J. (J'36), Practice Engr., Indus. Engrg. Dept., Carnegie-Ill. Steel Corp., Chicago; *for mail*, 4900 W. 28th Pl., Cicero.
NIBECKER, Karl ('08; '14; '35), V. P., Imperial Type Metal Co., 1800 S. 54th Ave.
TAYLOR, Geo. O. ('32; '35), Research Engr., Lubrication Corp., 910 S. Michigan Blvd., Chicago; *for mail*, 1832 S. 58th Ave., Cicero.

COLLINSVILLE, St. Louis Section

YOUTSEY, Floyd Stephens ('20), Cons. Engr., R. R. 2.

DECATUR

CANAVAN, William F. ('20), Pres., Leader Iron Works.
COOPER, Earl ('25), Ch. Engr., Chambers, Bering, Quinlan Co., 700 N. Jasper St.; *for mail*, 1588 W. Macon St.
MUELLER, Lucien W. ('36), V. P., Charge Factories, Mueller Co., 512 W. Cerro Gordo.
TERRY, Chas. M. ('25; '35), Ch. Engr., A. W. Cash Co., N. 18th St.; *for mail*, 240 W. Prairie Ave.

DEKALB, Rock River Valley Section

SHEELOR, Albert P. (J'36), M. E., Wurlitzer Grand Piano Co.

DES PLAINES, Chicago Section

HAZEN, Deane S. ('21; '26; '35), Comptroller & Asst. Secy., Benjamin Elec. Mfg. Co., Des Plaines; *for mail*, 203 Elmore Ave., Park Ridge.
STEELE, Walter D. ('92; '01), Pres., Benjamin Elec. Mfg. Co.

DOWNERS GROVE, Chicago Section

ANDERSON, Emil C. ('14), M. E., Charge, Loco. & Car Design, Chicago, Burlington & Quincy R. R., 547 W. Jackson Blvd., Chicago; *home address*, 4820 Oakwood Ave., Downers Grove.
BAER, Roy ('23; '35), Tivoli Hotel.

EAST ST. LOUIS, St. Louis Section

ANDERSON, Norman O. (J'35), Dean, Parks Air College.
DODSON, Rowland W. (J'20), V. P., M. E., Geo. S. Mepham Corp., 20th & Lynch Ave.
FARQUHAR, L. C. ('19; '35), Asst. Wks. Mgr., Am. Steel Fdys., 2039 E. Broadway.
HORNER, Chas. M. ('24), V. P., Gen. Mgr., E. St. Louis & Internatl. Motor Co.; *for mail*, 513 E. Missouri Ave.
ST. CLAIR, Fred'k G. (J'31), Furnace Oper., Union Elec. Light & Power Co., 12th & Locust Sts., St. Louis, Mo.; *for mail*, 810 N. 53rd St., E. St. Louis, Ill.

EFFINGHAM

JOHN, Edw. T. ('21; '30), 328 S. 5th St.

ELGIN, Chicago Section

GABRIEL, Wm. A. ('91), Retired; 570 E. Chicago St.
HUNTER, Geo. E. ('90), 325 Watch St.
KIRK, Geo. L. ('30), Supt. Mfg., Elgin Natl. Watch Co.; *for mail*, 1125 Bellevue Ave.
MALVERN, Lewis K. ('94; '03), Spec. Assignment Engr., Elgin Natl. Watch Co.; *for mail*, 12 Warwick Pl.
PRICE, Albert M. ('99; '04), Retired; 825 Douglas Ave.

EVANSTON, Chicago Section

CISLAK, John Francis (J'33), Student of Commerce, Northwestern Univ., Evanston; *for mail*, 1613 S. 50th Ave., Cicero.
CLOUSING, Lawrence A. ('33; '36), Instr., Mech. & Aero. Engrg., Sch. of Engrg., Northwestern Univ.
DUTTON, H. P. ('30), Prof. & Chmn. Social Sci. Dept., Armour Inst. of Tech.; Prof. Factory Mgmt., Northwest. Univ.; Consultant in Mgmt., Chicago; *for mail*, 2242 Pioneer Rd., Evanston.
KING, Chas. G. Y. ('91), Retired; 1744 Chicago Ave.
KNAPP, Wm. E. (J'35), 504 Lee St.
LINDBERG, Fritz A. ('08; '11). Ch. Engr., Gen. Engrg. Div., Armour & Co., Union Stock Yards, Chicago; *for mail*, 2725 Lincoln St., Evanston.
LOXTERMAN, H. R. (J'33), 1028 Austin St.
MARTEL, Jas. P. ('30), Asst. to V. P., Oliver United Filters, 221 N. LaSalle St., Chicago; *for mail*, 2002 Harrison St., Evanston.
PHILBRICK, Herbert S. ('07; '13), Prof. M. E., Northwestern Univ.; *for mail*, 2130 Sherman Ave.
RIDDELL, John Tate, Jr. (J'35), 1922 Sheridan Rd.
SCHMEISSER, Wilbur J. (J'35), 1713 Sherman Ave.
STOSSKOPF, Geo. W. (J'28), Mgr., Northwest. Bindery.
SWENSON, Carl. O. ('31), Engr. Charge Design. Phenix Equip. & Constr. Co., 1600 Foster St.

FREEPORT, Rock River Valley Section

NEELY, Wm. J. ('23), Plant Engr., W. T. Rawleigh Co.; *for mail*, 122 N. Grove Ave.
WEIGEL, Albert R. ('27), Life Member; Wks. Mgr., Charge Engrg. & Prod., Stover Mfg. & Eng. Co.

GLENCOE, Chicago Section

CARROLL, Emil J. ('18), Lieut., Ch. Deputy Procurement Officer, U. S. Treasury Dept., Merchandise Mart, Chicago; *for mail*, 128 Linden Ave., Glencoe.
COOKE, Bennett W. (A'24), Pres., Motor Inst. of Am., 333 Park Ave.

GLEN ELLYN, Chicago Section

DUNHAM, Walter E. ('14), Supt. Car Dept., Maint. & Design, Chicago & Northwestern Ry. Co., 4200 W. Kinzie St., Chicago; *home address*, 704 Main St., Glen Ellyn.
PARSONS, Leonard D., Jr. (J'36), 795 Park Blvd.

GRANITE CITY, St. Louis Section

DIETRICH, Chas. D. (J'28), Spec. Assignments, Gen. Steel Castings Corp., Granite City; *for mail*, 400 Walnut St., Pekin.
EVANS, Geo. B. ('14), Trustee in Bankruptcy, St. Louis Gas & Coke Corp., Granite City, Ill.; *for mail*, 275 N. Union St., St. Louis, Mo.
FREDE, Chas. F. ('18), Mgr. Prod., Commonwealth Div., Gen. Steel Castings Co., Granite City, Ill.; *for mail*, 7931 Gannon Ave., University City, Mo.
PFLAGER, H. M. ('33), Sr. V. P., Gen. Steel Castings Corp.
STOEVER, Alfred C. ('27; '35), M. E., Charge Power & Fuels, Granite City Steel Co., 20th & Madison Sts.
STREMMEL, Philip J. ('25), Gen. Supt., Granite City Steel Co., Granite City, Ill.; *for mail*, 6328 Emma Ave., St. Louis, Mo.
VOIGT, L. S. ('15; '25; '35), Master Mech., St. Louis Gas & Coke Corp.; *for mail*, 2216 E. 25th St.
WYLIE, John S. ('34; '36), Inspr., Hartford Steam Boiler Inspc. & Ins. Co., 617 Security Bldg., St. Louis, Mo.; *for mail*, 2474 State St., Granite City, Ill.

HARVEY, Chicago Section

GREGER, Arnold F. (J'27), 61 E. 155th St.
GUERASIMOFF, Constantine N. ('29; '32; '35), 15406 Broadway.
PIERCE, Conway ('22; '27; '35), 15717 Lexington Ave.
SEEDER, Carl ('29; '36), Plant Engr., Wyman-Gordon Co., 146th & Wood St.

HAZEL CREST, Chicago Section

O'HARA, Jos. P. (J'34), 16719 Lincoln St.

HOOPESTON

BASSLER, D. M. (J'35), 309 W. Penn.
EVERETT, H. L. (J'36), 3185—4th St.
FRASIER, J. Leroy (J'36), 318 S. 4th St.
GOLLMER, Carl E. (J'35), Engr. Design, Sprague-Sells Corp.; *for mail*, 318 S. 4th St.

HULL

HOYT, H. K. (J'35).

JOLIET, Chicago Section

ALLGAIER, Jos. M. (J'34), Indus. Engr., Moore Corp.; *for mail*, 122 Knox Pl.
CASTLE, Drew W. ('23; '32), Vocational Dir., Joliet Township High Sch. & Jr. College.
FERGUSON, Allan R. (J'34), Engr., Charge Design & Prod., Farrell Mfg. Co., Cass & Bissel Sts.
GOSSELIN, Edw. N. ('18; '23; '35), Pres. & Gen. Mgr., Phœnix Mfg. Co., Joliet, Ill. & Graver Tank & Mfg. Corp., E. Chicago, Ind.; *for mail*, 300 Richard St., Joliet.
SHAFFNER, Chas. R. ('16; '23; '30), Asst. Mgr., Carnegie-Ill. Steel Co., 208 S. LaSalle St., Chicago; *for mail*, 204 Hunter Ave., Joliet.

KEWANEE, Tri-Cities Section

BRONSON, Carlos E. ('15; '22), Ch. M. E., Kewanee Boiler Corp.
DICKSON, Jos. F. ('27), Ch. Draftsman, Kewanee Boiler Corp.
HARTMAN, John M. ('20; '30), Engr., Charge Research Lab., Kewanee Boiler Corp.
MATHER, Archie J. ('21), V. P., Charge Prod., Walworth Co., 313 N. Elm St.
McCARTHY, Harry ('09), Asst. Ch. Engr., Walworth Co.; *for mail*, 700 S. Chestnut St.
MOORE, Michael F. (A'15), Mgr., Kewanee Boiler Corp.
QUIRKE, Edw. D. ('11), Adv. Mgr., Kewanee Boiler Corp.; *for mail*, 730 S. Chestnut St.
TERRY, Chas. D. ('02; '08), Secy. & Treas., Boss Mfg. Co., 1st & Chestnut Sts.; *for mail*, 522 S. Tremont St.

LA GRANGE, Chicago Section

BOCKSTAHLER, L. A., Jr. (J'35), Shop Work, Electro-Motive Corp., La Grange, Ill.; *for mail*, 2923 Southington Rd., Shaker Heights, Cleveland, Ohio.
RONOWSKI, Robt. Peter (J'34), 410 N. Edgewood Ave.
SENCEBAUGH, Clarence K. ('22; '35), Dist. Sales Engr., Buckeye Mch. Co., Lima, Ohio; *for mail*, 208 N. Kensington Ave., La Grange, Ill.
WEIFFENBACH, Jack F. (J'34), M. E. Design, Electro-Motive Corp., P. O. Box M.
ZIMMERMAN, Oliver B. ('05), Engr., Charge Research & Cons., Johnson & Co., 333 N. Michigan Ave., Chicago; *for mail*, 324 S. Ashland Ave., La Grange.

LAKE FOREST, Chicago Section

JULIAN, Melvin D. (J'34), 123 Stone Gate Rd.
MOORE, C. Herbert (J'35), 6 College Campus.
STEWART, J. T. (J'33), Prod., W. C. Ritchie & Co., Baltimore St., Chicago; *for mail*, Box 462, Lake Forest.

LOMBARD, Chicago Section

STANFORD, R. F. (J'36), 197 Craig Pl.

LYONS, Chicago Section

POLKO, Peter Paul (J'34), 4342 S. Oak Ave., P. O. Box 626.

MARSHALL

STANTON, Robt. E. (J'36), Velsicol Corp.

MOLINE, Tri-Cities Section

BATTLES, Geo. W. (J'30), Designing Engr., Deere & Mansur Wks., Moline; *for mail*, 1011—2nd Ave., Rock Island.
CARLSON, Chas. A. ('14; '35), M. E., John Deere Plow Wks., 3rd Ave. & 13th St.; *for mail*, 1414—14th St.
CROSS, R. A. ('21; '35), Plant Engr., Union Malleable Iron Co., E. Moline; *for mail*, 2335—23rd Ave., Moline.
EKSTROM, Carl W. (J'35), Asst. M. M., Charge Design, John Deere Spreader Wks., E. Moline; *for mail*, 1322—13th St., Moline.
ERICKSON, Erick Gustaf ('28; '35), Engr., Charge Design & Pur., Buddy "L" Co., 1300 Block & 5th St., E. Moline; *for mail*, 2419—11th Ave. A, Moline.
FINK, Henry (J'27), Mech. Engr., Moline Tool Co., 102—20th St., Moline; *for mail*, 1561—41st St., Rock Island.
HUNT, Wilson P. ('13; '21), Pres., Mgr., Moline Tool Co., 102—20th St.
JOHNSON, Wayne G. (J'36), Asst. Research Engr., Herman Nelson Corp.
KLEINMAN, Harold A. ('28), Engr., Charge Prod., Peoples Power Co., 14th St. & 5th Ave.; *for mail*, 2727—15th Ave.
LASHBROOK, Thos. S. (J'35), Time Study Engr., John Deere Harvester Wks., E. Moline; *for mail*, 715—16th St., Moline.
LINDBERG, A. E. ('20; '35), Ch. Engr. & V. P., Moline Tool Co., 102—20th St.; *for mail*, 2410—14th Ave.
McGOWN, John A. (J'34), 431—16th Ave., E. Moline.
NELSON, R. H. (J'28), Secy.-Treas., Herman Nelson Corp.; *for mail*, 1303—30th St.
ROSBOROUGH, Caldwell R. ('13; '21), Pres., Gen. Mgr., Moline Tool Co., 102—20th St.; *for mail*, 1235—11th Ave.
ROYS, Lawrence ('07; '21), Pres., West. Struc. Co.; *for mail*, 825—27th St.
ST. CLAIR, Clinton D. ('20; '26; '35), Mgr., Tolhurst Div., Am. Mch. & Metals, Inc., E. Moline; *for mail*, 1203—24th Ave., Moline.
SHORT, Merle K. (J'36), Tool Designer, Herman Nelson Corp., 1616—9th Ave.
SKLOVSKY, Max ('22), Ch. Engr., Deere & Co.
SOUCEK, Jaro L. (J'36), Designer, John Deere Harvester Wks., E. Moline, Ill.; *for mail*, 1014 N. Summit St., Iowa City, Iowa.
WINHOLT, Einar ('28), Supvg. Power Engr., Deere & Co.; *for mail*, 1815—25th Ave.

MONSANTO, St. Louis Section

BACON, Lewis F. ('21), Plant Supt., Monsanto Chem. Co., Monsanto, Ill.; *for mail*, Mark Twain Hotel, St. Louis, Mo.
SEIFERT, Richard W. (J'28), Asst. Plant Engr., Monsanto Chem. Co., Monsanto, Ill.; *for mail*, 639 Scott Ave., Kirkwood, Mo.

MORRISON, Tri-Cities Section

ALLEMANG, Herbert John ('33; '35), Gen. Mgr., Ice Cooling Appliance Corp.

OAKLAND

PEMBERTON, Carlysle ('12; '25; '35), City Engr.

OAK PARK, Chicago Section

BEESON, Foster N., Jr. (J'35), Engr., W. Pullman Wks., Internatl. Harvester Co., Chicago; *for mail*, 144 S. Cuyler Ave., Oak Park.
CAMERON, Geo. C. ('33), Examining Engr., Reconstruction Finance Corp., 1825 H St., N. W., Washington, D. C.; *for mail*, 212 S. Marion St., Oak Park, Ill.
CHRISTMAN, John Wm. (J'34), 424 S. Harvey Ave.
DOKE, George E. ('19; '21), Retired; 310 N. Grove Ave.
GEITMANN, Russell J. (J'29), Estimating Engr., Link-Belt Co., Chicago; *for mail*, 140 Harrison St., Oak Park.
JOHNSON, Harley A. ('34), Gen. Mgr., for Receivers, Chicago Rapid Transit Co., 72 W. Adams St., Chicago; *for mail*, 322 S. Oak Park Ave., Oak Park.
KARLSSON, Rudolph ('28; '35), 813 Forest Ave.
KRUEGER, Harold F. (J'29), Engr., A. B. Segur & Co., 1185 S. Ridgeland Ave.
LINK, Maximilian W. ('17), Dir., Research & Devel. Div., Crane Co., 836 S. Michigan Ave., Chicago; *for mail*, 175 N. Lombard Ave., Oak Park.
MAY, Edward M. ('31), 1022 N. Hayes Ave.
NIEDERMAN, Philip H. (J'28), 316 N. Ridgeland Ave.
SEGUR, A. B. ('19; '35), Indus. Engrg., A. B. Segur & Co., 1185 S. Ridgeland Ave.

OREGON, Rock River Valley Section

ETNYRE, Saml. R. (J'28), M. E., Charge Design, E. D. Etnyre & Co., 2nd & Jefferson.

OTTAWA

GUTHRIE, A. N. (J'35), Combustion Engr., Libbey-Owens-Ford Glass Co.; *for mail*, 818 Congress St.
REESE, Woeber J. (J'32), Engr., Charge Dredging, Al. Johnson Constr. Co., Foshay Tower, Minneapolis, Minn.; *for mail*, 842 Congress St., Ottawa, Ill.

PARK RIDGE, Chicago Section

RHINEHART, John R. ('23; '30; '33), 1005 S. Greenwood Ave.

PEKIN

TURNER, Chas. P. (A'07), Installation Supvr., Gen. Elec. Co., Chicago; *for mail*, 418 Park Ave., Pekin.

PEORIA

ACKERMAN, Wm. L. (J'34), Draftsman, Keystone Steel & Wire Co.; *for mail*, 1301 Moss Ave.
BENNER, Paul B. (J'33), Student Engr., Caterpillar Tractor Co.; *for mail*, 715 Hanssler Pl.
BIGGS, W. F. ('35), Power Engr., Hiram Walker & Sons, Inc., Foot of Edmund St.
BROWN, G. Bentley ('24; '35), M. E., Engr. in Charge, Commercial Solvents Corp.
BROWNE, Wm. H. (J'36), M. E., Apprentice Engr., Caterpillar Tractor Co.; *for mail*, 1310 Main St.
BUCHANAN, Wm. C. ('18; '35), 419 Columbia Terrace.
DAVIS, Chas. A., Jr. (J'33), Engr., Charge Specifications, Stands., Caterpillar Tractor Co., E. Peoria; *for mail*, 233 Crescent Ave., Peoria.
EDWARDS, Earl D. ('25; '35), Supt. Power, Cent. Ill. Light Co., 316 S. Jefferson Ave.
ESCHER, W. F. (J'34), Apt. B-3, 508 Knoxville.
FOSTER, Winnie N. (J'34), 1321 E. Nebraska Ave.
GLIMM, Wm. F., Jr. ('17; '26; '35), Ch. Engr., Barrett Co., Foot of Clark St.
HARPER, Edwin C. (J'36), Engr. Apprentice, Caterpillar Tractor Co., Peoria; *for mail*, 223 E. Washington, E. Peoria.
HEBDEN, Frank S. ('23; '35), 1900 Main St.
KNIESE, Harold G. ('17; '21; '30), Constr., Engr., Cent. Ill. Light Co., 316 S. Jefferson St.; *for mail*, Apt. 4, 736 Linn St.
LUX, Arthur E. (J'36), Apprentice Engr., Caterpillar Tractor Co.; *for mail*, 1325 Moss Ave.
McCLAIN, Richard E. (J'36), Apprentice Engr., Caterpillar Tractor Co.; *for mail*, 315 N. Elmwood.
MEES, Robt. T. (J'32), Design Engr., Asst. to Tractor Engr., Caterpillar Tractor Co., E. Washington, E. Peoria; *for mail*, 303 Barker Ave., Peoria.
MEYER, Frank L. (J'27), V. P., Charge Engrg., Prod., Meyer Furnace Co.; *for mail*, 9 Cole Court.
MULREY, Maurice D. (J'32), Engrg., Caterpillar Tractor Co., Peoria, Ill.; *for mail*, 3161 N. Illinois St., Indianapolis, Ind.
NEWELL, John C. ('17; '35), Ch. Engr., Keystone Steel & Wire Co.
NICHOLS, DeOwen, Jr. (J'36), c/o Mrs. H. E. Chubbuck, Grand View Dr.
SHAKMAN, Jas. G. ('21; '35), Box 1017.
WALLACE, Ross S. ('04), Pres., Cent. Ill. Light Co., 316 S. Jefferson Ave.
WEEKS, Col. Paul ('05; '11), Mgr., Eng. Sales Div., Caterpillar Tractor Co.; *for mail*, 124 Barker Ave.
WEINER, L. P. (J'30), M. E., Plant Supt., Hiram Walker & Sons, Inc., Foot of Edmund St.; *for mail*, 203 N. Maplewood Ave.
WITT, L. Herndon (J'32), Merchandise Bur., Caterpillar Tractor Co.; *for mail*, 412 W. McClure Ave.
WOODFILL, C. R. (J'33), Power Plant, Commercial Solvents Corp.; *for mail*, 128 Gilbert.

PERU

NEUREUTHER, Andrew H. ('99; '28), Cons. Engr., West. Clock Co., 4th St.; *for mail*, 1511—4th St.

PITTSFIELD

WRIGHT, J. W. (J'35).

PONTIAC

WALLACE, Geo. Q. (J'34).

QUINCY

OLSON, Don L. (J'34), Sales Engr., Gardner-Denver Co., 1353 W. Washington Blvd., Chicago; *home address*, 5511 W. Washington Blvd., Quincy.
TERWELP, E. J. ('28; '35), M. E. & Draftsman, Miss. River Dam No. 21, Quincy, Ill., for McCarthy Improvement Co., of Davenport, Iowa; *for mail*, 1825 Chestnut St., Quincy.

RIVER FOREST, Chicago Section

HUBBARD, Geo. W. ('13), 710 Bonnie Brae.
MATLACK, Ellwood V. ('04), Life Member; 223 Keystone Ave.

RIVERSIDE, Chicago Section

EGLOFF, Frank (J'34), Prod. & Cost Analyst, Tool Design, T. A. Koch Co., 679 N. Wells St., Chicago; *for mail*, 215 Olmstead Rd., Riverside.
HARRINGTON, Jos. ('13), Pres., Gen. Mgr., Harrington Heater Co.; *for mail*, 325 Gage Rd.
LUKEY, John Bernard (J'34), 396 Uvedale Rd.
WHITING, Richard A. ('09; '18), Power Engr., Pub. Serv. Co. of No. Ill., 72 W. Adams St., Chicago; *for mail*, 292 Shenstone Rd., Riverside.

ROCKFORD, Rock River Valley Section

AVERY, Clarence L. ('30; '35), Engr., Woodward Governor Co.; *for mail*, 518 Fisher Ave.
BETTS, Wilbur W. (J'35), 1526 Huffman Blvd.
BURCH, Arthur M. (J'30), Sales Analyst, Ingersoll Milling Mch. Co., Rockford, *for mail*, 203 Washington Blvd., Oak Park.
GEDDES, Leslie H. ('34), Sales Mgr., Greenlee Bros. & Co., 12th St.
HANITZ, H. T. ('27), Design Engr., Ingersoll Milling Mch. Co.; *for mail*, 5236 East Dr.
HUYSER, Francis C. (J'34), Draftsman, Ingersoll Milling Mch. Co.; *for mail*, 510 Francis Ave.
JOHNSON, Albert M. ('22), V. P. & Ch. Engr., Charge Design, Barnes Drill Co., 814 Chestnut St.; *for mail*, 1922 Clinton St.
JOHNSON, B. E. (J'19), Family Theatre.
JOHNSON, John R. ('24), Supt., Ingersoll Milling Mch. Co.
KRAUS, Chas. ('33; '35; '35), Ingersoll Milling Mch. Co.
LYON, Arthur H. ('28), Ch. Engr., Ingersoll Milling Mch. Co.; *for mail*, 2212 Harlem Blvd.
MANSFIELD, Judson H. ('27), Ch. Engr., Charge Design, Greenlee Bros. & Co.
MASON, Carrington (J'31), Sales Analyst, Ingersoll Milling Mch. Co., Douglas & Willoughby.
MATTISON, Alan C. (J'30), Shop Supt., Mattison Mch. Wks., Blackhawk Ave.
MORGAN, Everette K. ('18; '23), Charge Sales Analysists, Ingersoll Milling Mch. Co.
PETERSON, Burt A. ('31), Experimental Engr., Barber-Colman Co.; *for mail*, 1960 Harlem Blvd.
PURDY, Geo. C. ('30), Pres., Greenlee Bros. & Co.
RIDDIFORD, Arthur B., Jr. (J'31), Engr., Asst. in Design & Devel., W. F. & John Barnes Corp., S. Water St.; *for mail*, 1318 Camp Ave.
SHEDD, Ward R. ('21), Plant Engr., Barber-Colman Co.; *for mail*, 719 Ashland Ave.
STENSTROM, Arnold E. (J'34), 811—6th Ave.
STRAWN, Marion L. ('22; '28), Sales Supvr., Ingersoll Milling Mch. Co.; *for mail*, 1507 Harlem Blvd.
WEDDELL, Ralph R. ('20; '26; '35), Mgr., Small Tool Div., Ingersoll Milling Mch. Co.

ROCK ISLAND, Tri-Cities Section

DAASCH, Francis J. (J'36), Engr., Shop & Specifications, Corps of Engrs., War Dept., Clock Tower Bldg.
O'CONOR, Frank (J'33), Jr. Engr., Corps of Engrs., War Dept., Clock Tower Bldg.
STRICKLAND, Bert ('28), Elec. Supt., Rock Island Arsenal, Rock Island, Ill.; *for mail*, 1115 E. High St., Davenport, Iowa.

SCHELLER

SKORTZ, A. C. (J'34), Engr., Charge X-Ray, J. P. Devine Mfg. Co., Mt. Vernon; *for mail*, Scheller.

SPRINGFIELD

BANCK, Hans J. E. ('21), Ch. Engr., Springfield Boiler Co.; *for mail*, 1524 Dial Court.
DURAM, Arthur E. ('16), Sales Engr., Springfield Boiler Co., 1900 Capitol Ave.
FLENTIE, J. L. (J'35), 819 E. Capitol.
KING, Frank A. ('17; '26), 1033 S. Walnut St.
MAGRAW, Lester A. ('20), Pres., Cent. Ill. Pub. Serv. Co., Rm. 1228, Illinois Bldg.
MUERLE, Richard W. ('35), Engr., Charge Design & Devel., Hummer Mfg. Co., 9th & S. Grand Sts.; *for mail*, 905 Bryn Mawr Blvd.
SWANNACK, Jervis Daniel (J'35), Student M. E., Allis-Chalmers Mfg. Co.; *for mail*, 719-D E. Capitol Ave.
Von BARGEN, Otto (J'34), 818 E. Capitol Ave.
WILSON, Marshall Albert (J'30), M. E., City Water, Light & Power Dept., City Hall; *for mail*, 2416 S. 4th St.

STERLING

KARR, Irvin C. (J'35), 809 E. 2nd St.

URBANA

BETTY, Bernard Breast (J'30), Research Engr., Engrg. Exper. Sta., Matls. Testing Lab., Univ. of Ill.
BROOKS, Morgan ('85), Life Member; Prof. E. E., Emeritus, Univ. of Ill.; *for mail*, 1105 W. California Ave.
CASBERG, Carl H. ('21; '28), Prof. M. E., Shop Lab., M. E. Dept., Univ. of Ill.
DOLAN, Thos. J. (J'36), Instr., Theory & Applied Mechanics, 811 Matls. Testing Lab., Univ. of Ill.
ENGDAHL, Richard (J'36), Research Asst., M. E. Dept., Univ. of Ill.; *for mail*, 1108 W. Stoughton St.
ESPY, Wm. N. ('21; '35), Asst. Prof., M. E. Dept., Univ. of Ill.; *for mail*, 608 W. Nevada St.
GOFF, John A. ('29; '35), Prof. Thermodynamics, 217 Transportation Bldg., Univ. of Ill.
HAM, C. W. ('16), Prof. Mch. Design, Univ. of Ill., 113 Transportation Bldg.
KNOX, Walter (J'34), 911 W. High St.
KRATZ, A. P. ('13; '21), Research Prof., M. E. Dept., Univ. of Ill.
LARSON, Reinhold F. (J'30), Instr., M. E. Dept., Univ. of Ill.
LEUTWILER, O. A. ('04; '11), Prof. M. E. Design & Head of M. E. Dept., Univ. of Ill.; *for mail*, 710 Pennsylvania Ave.
MOHN, Paul E. ('28; '34), Asst. Prof. M. E., Univ. of Ill., 103 M. E. Lab.
MOORE, Herbert F. ('13), Research Prof. of Engrg. Matls., Univ. of Ill.
POLSON, Jos. A. ('06; '12), Steam Engrg., M. E. Dept., 207 M. E. Lab., Univ. of Ill.
REED, John C. (J'28), Assoc. in M. E., Univ. of Ill., 205 M. E. Lab.
SCHMIDT, Edw. Chas. ('08), Prof. & Head, Dept. Ry. Engrg., 101 Transportation Bldg., Univ. of Ill.
SEELY, Fred B. ('27), Head, Dept. Theoretical & Applied Mechanics, Univ. of Ill., Matls. Testing Lab.
SEVERNS, Wm. H. ('16; '21), Prof. M. E., Univ. of Ill.; *for mail*, 609 W. Indiana Ave.
STARR, Chas. J. ('19; '35), Assoc. M. E., Univ. of Ill.; *for mail*, 606 W. Nevada St.
TALBOT, Arthur N. ('14), Prof. Emeritus, Univ. of Ill.; *for mail*, 1113 W. California Ave.
THOMAS, Fred'k Hayward ('29; '32), Asst. Prof. M. E., Univ. of Ill.; *for mail*, 406 W. High St.
VIERCK, Robt. K. (J'36), Jr. Engr., 301 Transportation Bldg., Univ. of Ill.
WILLARD, Arthur C. ('19), Pres., Univ. of Ill.
YOUNG, E. G. ('19; '24), Research Prof., Ry. M. E., Univ. of Ill., 102 Transportation Bldg.

WAUKEGAN, Chicago Section

BANTA, John S. ('12), Dist. Engr., Chicago, Am. Steel & Wire Co.; *for mail*, 930 Hickory St.

WHEELING, Chicago Section

WENGHOFER, Jos. David (J'33).

WILMETTE, Chicago Section

BILLOW, Clayton O. ('14), Retired Cons. Engr., 1212 Ashland Ave.
ERMELING, Lewis B. ('19; '25), Secy., Treas., Chicago Hotel Assn., 58 E. Congress St., Chicago; *for mail*, 1305 Greenwood Ave., Wilmette.
FITCH, Claude E. ('02), M. E., 1033 Elmwood Ave.
LeMONT, Frank H. (A'22), Pres., Mgmt. Serv. Co., 2232 Elmwood Ave.

WILMINGTON, Chicago Section

LEONARD, Arthur G., Jr. (J'28), Secy., Orenda Corp.

WINNETKA, Chicago Section

STEPHENSON, Paul A. ('30; '32; '35), 126 Fuller Lane.
WESTERVELT, Col. Wm. I. ('15), 465 Poplar St.

WOOD RIVER, St. Louis Section

VUNCK, Douglas C. (J'36), Jr. Asst. Technologist, Shell Petroleum Corp.; *for mail*, 344 Lorena Ave.

INDIANA

ANDERSON, Central Indiana Section

ABBOTT, Ralph G. (J'30), Field & Sales Engr., Factory Engrg., Pierce Governor Co.
BECKER, Chas. S. (J'34), 904 W. 4th St.
GROSS, Claude M. ('27), Plant Engr., Delco-Remy Corp.; *for mail*, R. R. 5.

ANGOLA

OTT, Luther A. ('31), Head, Dept. Aero Engrg., Officer of Tri-State College; *for mail*, Tri-State College, College Hill.

AUBURN

DWIGHT, Ralph W. ('31), 809 N. Main St.

CLINTON, Central Indiana Section
SASSO, Chas. C. (J'33), 438 N. 7th St.

COLUMBUS, Central Indiana Section
CUMMINS, Clessie L. ('31), Pres., Cummins Eng. Co.; *for mail*, 718—7th St.
DURRSTEIN, Vernon L. (J'32), Research Engr., Cummins Eng. Co.; *for mail*, 630 7th St.
HOERNES, Helmut ('31; '35), Designer, Cummins Eng. Co.; *for mail*, 911 Chestnut St.
McMULLEN, V. E. ('07; '11), 2026 LaFayette Ave.
NIEDERAUER, Howard H. (J'30), Reeves Pulley Co., 1225 E. 7th St.
SEEWER, Ernest U. ('34; '35), Asst. Ch. Engr., Cummins Eng. Co., 5th St.; *for mail*, 1522 Lawton Ave.
WORTH, Daniel B. (J'21), M. E., Eng. Application & Design, Cummins Eng. Co.; *for mail*, 1704 Franklin St.

CONNERSVILLE, Central Indiana Section
BRYANT, Lorton W. (J'35), Asst. Engr., "T" Pump Dept., Roots-Connersville Blower Corp.; *for mail*, 1132 Central Ave.
HOUGHTON, C. R. ('20), Engr., Charge Research, Roots-Connersville Blower Corp.; *for mail*, 1622 Virginia Ave.
ROTH, Eugene (J'32), Engr., Charge Design, Stant Mfg. Co.
TATMAN, Jas. S. ('27), Pres. & Gen. Mgr., Roots-Connersville Blower Corp.

EAST CHICAGO, Chicago Section
BANTA, T. C. (J'34), Asst. Ch. Designing Engr., Sinclair Refining Co.
BERGNER, H. W. (J'36), Asst. Mech. Foreman, Inland Steel Co., E. Chicago, Ind.; *for mail*, 6902 Anthony Ave., Chicago, Ill.
CAMPBELL, Oliver F. ('29; '35), Combustion Engr., Sinclair Refining Co.
CORNELL, Dana Robt. ('18; '21; '35), Wks. Mgr., Stand. Forgings Co.
CRAWFORD, Wm. W. ('24; '28), Pres., Edw. Valve & Mfg. Co., Inc., E. Chicago, Ind.; *for mail*, 7116 Coles Ave., Chicago, Ill.
FERRIS, John T. ('21; '30), Indus. Engr., Youngstown Sheet & Tube Co.
HAHN, Archie, Jr. (J'36), E. I. du Pont de Nemours & Co., Indus. Engr., Grasselli Chem. Dept., E. Chicago; *for mail*, 5945 Park Pl., Hammond.
LUNEY, Frank S. ('36), Engrg. Dept., Sinclair Oil Co., E. Chicago; *for mail*, 6347 Van Buren Ave., Hammond.
MOHR, W. W. ('29), Ch. Engr., Edw. Valve & Mfg. Co., Inc.
RINGGENBERG, Herman I. ('27; '35), Sinclair Refining Co.
ROSENAK, Irwin (J'33), Draftsman, Elec. Constr., Inland Steel Co.; *for mail*, 4865 Indianapolis Blvd.
STROSS, Chas. H. (J'33), Combustion Engr., Williams Bros. & Miller, Inc., 4815 Indianapolis St.
THOMSON, Jas. ('21), Ch. Plant Engr., Continental Roll & Steel Fdy. Co.; *for mail*, 4130 Magoun Ave.
UNTERMYER, Saml., 2nd (J'34), Asst., Charge Eng. Lab., Sinclair Refining Co.
WILLIAMS, Arthur ('36), Research Engr., Superheater Co., 151st St. & R. R. Ave.

ELKHART, St. Joseph Valley Section
BACHMAN, Wm. A. ('22), Edy. Supt., N. Y. Cent. R. R. Co.; *for mail*, 1440 Greenleaf Blvd.
BFERS, Otis E. ('30), Gen. Mgr., Buescher Band Instrument Co.; *for mail*, 159 Gage Ave.
GREENLEAF, Leland B. (J'30), Ch. Engr., Charge Design, Maint., Tools, C. G. Conn. Ltd.; *for mail*, 1496 Greenleaf Blvd.
HUNTER, Chas. F. ('17), Dist. Mgr., No. Ind. Pub. Serv. Co., 300 S. Main St.
LOOMIS, Allen ('20), Exper. Engr., C. G. Conn. Ltd.; *for mail*, 915 E. Beardsley Ave.

EVANSVILLE
BAUER, Chas. A. (J'25), Mgr., Plastics Div., Hoosier Lamp & Stamping Co.
SHUART, Arthur C. ('31; '35), Ch. Draftsman, Servel, Inc.; *for mail*, 514 Villa Dr.
STONE, H. L. (J'34), Maint. & Design, Mead Johnson & Co.; *for mail*, 2725 Marion Ave.

FORT WAYNE
AUMANN, Erwin Wilhelm F. (J'32), Gen. Elec. Co.; *for mail*, 725 E. Jefferson St.
BIRDSONG, John M. (J'36), Mfg. Stands. Dept., Gen. Elec. Co.; *for mail*, 1811 Thompson St.
BUCK, Everett S. ('31), Owner, Fort Wayne Air Conditioning Co., 223 E. Main St.
JOHNSON, Wilfrid E. ('30; '34; '35), Mem. Design Dept., Refrig. Engrg., Gen. Elec. Co., 1605 Winter St.
MATSON, Clifford H. ('20; '29), Gen. Supt., Mfg., Gen. Elec. Co., 1635 Broadway.
McVEY, Delbert P. (J'24), Lubricating Sales Engr., Gulf Refining Co., 2935 Front St., Toledo, Ohio; *for mail*, 4202 Hoagland Ave., Fort Wayne, Ind.
WILSON, Dale G. (J'29), Equip., Cost Control Engr., Gen. Elec. Co.; *for mail*, 918 N. Anthony Blvd.

GARY, Chicago Section
ANDERSON, Howard L. ('07; '16), 1601 W. 5th Ave.
BAILEY, Chas. Alonzo (J'36), 448 Harrison St.
BURRESS, Lloyd F. (J'17), Supt., Coke Plant, Carnegie-Ill. Steel Corp.
DIERDORF, Claude C. (J'36), Carnegie-Ill. Steel Corp.; *for mail*, 411 W. 8th Ave.
DOTSON, Chas. C. (J'35), Practice (Spec.) Apprentice, Carnegie-Ill. Steel Corp.; *for mail*, 728 Connecticut St.
MARMONT, E. Leonard (J'34,), Designer Draftsman, Gary Sheet Mill, Carnegie-Ill. Steel Corp.; *for mail*, 729 Buchanan St.
MAURER, Henry L. (J'34), 405 Bridge St.
MAZURIE, J. V. ('29), Ch. M. E., Natl. Tube Co.
ORR, Howard S. (J'32), 446 Marshall St.
STENTZ, Frank W. ('28), Natl. Tube Co.; *for mail*, 703 Grant St.
THIEL, Wm. A. ('26; '35), Office Mgr., M. M. Dept., Am. Bridge Co.; *for mail*, 225 Chase St.

HAGERSTOWN, Central Indiana Section
MARSH, Harry B. ('18), Statistician, Perfect Circle Co.
TEETOR, Ralph R. ('13; '21; '35), Charge Engrg., Perfect Circle Co.; *for mail*, 10 W. Main St.

HAMMOND, Chicago Section
CLEAVENGER, Wm. D. ('21), Mech. Supt., Youngstown Sheet & Tube Co., E. Chicago; *for mail*, 6323 Forest Ave., Hammond.
DEETHARDT, Theo. R. (J'31), Effic. Engr., Chicago Dist. Elec. Generating Corp., Box 65, Hammond, Ind.; *for mail*, 10529 Avenue F, Chicago, Ill.
HALL, J. Robt. ('23; '35), Boiler House Foreman, Shell Petroleum Corp., E. Chicago; *for mail*, 6626 Monroe Ave., Hammond.
HALL, R. Benson ('19; '34), M. E., Gen. Engrg. Serv., P. O. Box 7.
KREJCI, Emil L. (J'26), M. E. Design, Am. Steel Fdys., Hohman Ave., Hammond, Ind.; *for mail*, 2548 Indiana Ave., Lansing, Ill.
UMBEHOCKER, Frank ('21; '29), Ch. Oper. Engr., Chicago Dist. Elec. Generating Corp., P. O. Box 65; *for mail*, 47—172nd Pl.

HARTFORD CITY, Central Indiana Section
STEVENS, G. D. ('19), Plant Engr., Ft. Wayne Corrugated Paper Co.

HUNTERTOWN
YOUNG, Geo. S. (J'33), c/o G. A. Young, R. 1.

HUNTINGTON
SOMERS, Howard A., Jr. (J'31), Supt., Ind. Pipe Line Co.

INDIANAPOLIS, Central Indiana Section
ATKINSON, Robt. P. (J'35), 2534 Broadway.
BAKER, Hugh J. ('19), Pres. & Gen. Mgr., Hugh J. Baker & Co., 602 W. McCarty St.
BARLOW, Cone ('32), Sales Engr., Sinker Davis Co., 230 S. Missouri St.
BROSSMAN, Charles ('18), Cons. Engr., Chamber of Commerce Bldg., 312 N. Meridian St.
BRYANT, Jerrus M. ('27; '35), Asst. Ch. Engr., Link-Belt Co., 515 Holmes Ave.; for mail, 4011 Broadway.
BUCHANAN, M. O. (J'32), Inspr., Hartford Steam Boiler Inspc. & Ins. Co., Hartford, Conn.; *for mail*, 1914 W. Wyoming St., Indianapolis, Ind.
CARNES, Herman W. (J'29), Engr., Design & Devel., Prest-O-Lite Co., Inc.
CHANDLER, Robt. (J'34), Mgr., Order Dept., Paper Package Co.
CUNNING, Jas., Jr. (J'33), Boiler Rm. & Power Plant, Kingan & Co., Blackford St.; *for mail*, 3351 N. Meridian St.
DRAKE, Robt. W. ('17; '35), M. E. & E. E., Design & Constr., Rockwood Mfg. Co., 1801 English Ave.; *for mail*, 1022 Garfield Dr.
GOLD, David (J'36), 1601 Columbia Ave.
GORRIE, John M. ('31; '35), Engr., Travelers Indemnity Co., Main St., Hartford, Conn.; *for mail*, 35 S. Denny St., Indianapolis, Ind.
GRIMMER, Ernest A. ('21; '31), Sales Rep., Lathrop-Trotter Co., 1340 Union Trust Bldg., Cincinnati, Ohio; *for mail*, 519 Chamber of Commerce Bldg., Indianapolis, Ind.
GRISBAUM, Leonard D. ('17; '23; '35), Charge Engrg., Research, Ry. Serv. & Supply Corp., 510 S. Harding.
HANLEY, Wm. A. ('13; '20; F'36), Manager, '27-'30; Vice-President, '30-'32; Dir. of Engrg., Eli Lilly & Co.
HANNEWALD, Burton (J'26), Asst. Supt. Mch. Shop., Bemis Bros. Bag Co., 1940 Barth Ave.; *for mail*, 1461 Linwood Ave.
HARTLEY, Harry D. ('10; '21; '34), 1404 Merchants Bank Bldg.
HEIDENGER, Henry W. ('21), 2907 W. Washington St.
KRANNERT, Herman C. ('17; '35), Pres. & Gen. Mgr., Inland Container Corp., 700 W. Morris St.
LADD, Geo. H. (J'31), Matl. Supvr., Inland Container Corp., 700 W. Morris St.; *for mail*, 5207 E. Washington St.
LANGFITT, Jos. K. ('20), Wks. Engr., Link-Belt Co., 220 S. Belmont St.; *for mail*, 4625 Park Ave.
LAWRENCE, L. E. ('29; '35), Engr., P. R. Mallory & Co., Inc., 3029 E. Washington St.; *for mail*, 401 E. 37th St.
McANINCH, Herbert A. (J'34), 5346 Keystone Ave.
NULSEN, Marvin E. ('21; '27), V. P., P. R. Mallory & Co., Inc.; *for mail*, 312 N. Kenyon Ave.
OLSON, Malven Leonard (J'36), Jr. Engr., Charge Design, Prest-O-Lite Co., Inc., 16th & Main St., Speedway; *for mail*, 5222 W. 14th St.
PEARCE, Bert L. (J'35), Link-Belt Co., 519 N. Holmes; *for mail*, 4820 Broadway.
PEARCE, Edwin S. ('15; '25), Pres., Ry. Serv. & Supply Corp., 510 S. Harding St.
PEASLEE, W. D. A. ('21; '30), 3128 N. Pennsylvania St.
RICHHART, Wm. S. ('19), Ch. Engr., Indiana Statewide REMC, 309 W. Washington St.; *for mail*, 615 E. 32nd St.
RIGGS, John D. (J'92), Designer, R. 18, Box 298.
RUPARD, Homer ('22; '29; '35), Asst. Ch. Engr., Indianapolis Water Co., 113 Monument Circle.
SALZMAN, Carl E. (J'33), Engrg. Draftsman, Dodge Plant, Link-Belt Co., Indianapolis, Ind.; *for mail*, 1023 S. 17th St., Fort Smith, Ark.
SCHEPMAN, W. G. (J'36), Jr. Engr., Prest-O-Lite Co., Speedway.
SIEGESMUND, John C. ('24; '30), Asst. Dir. Engrg., Eli Lilly & Co.; *for mail*, 61 Campbell Ave.
SKABO, Hans H. ('27; '30), Dist. Mgr., Republic Flow Meters Co., 519 Chamber of Commerce Bldg.
SKINNER, Oramel H. ('18), Treas., Thomas & Skinner Steel Products Co., 1120 E. 23rd St.
SMITH, Wilbert C. ('22; '26; '35), Lub. Engr., Pure Oil Co., 810 Test Bldg.
SNEDEN, Horace J. ('28), Supt. Power Plants, Indianapolis Power & Light Co.; *for mail*, 651 E. 32nd St.
TAYLOR, Wm. Mode ('88; '04), Sales Mgr., Maluminum Co., Transportation Bldg.; *for mail*, 1449 N. Delaware St.
UPDIKE, Ronald (J'34), 1526 E. 12th St.
WALL, Wm. G. ('07), Cons. Engr., 522 Merchants Bank Bldg.
WATSON, Jas. S. ('21), V. P., Gen. Mgr., Link-Belt Co., P. O. Box 85.
WEAVER, Frank R. ('23), Indus. Consultant; also Mgr., Hibben, Hollweg & Co., 110 S. Meridian St.; *for mail*, 1415 Golden Hill Dr.
WIMBOROUGH, Jas. R. (J'36), Draftsman, Ind. Highway Survey Comm., 403 Old Trails Bldg., Indianapolis; *for mail*, 1003 N. Meridian St., Lebanon.
WYNNE, Thos. N. ('19; '23), Pres., Treas., Metal Furnace Block Corp., 728 Illinois Bldg.
ZIETLOW, Fred P. (J'33) Engr., Charge Design, H. F. Zietlow Co., 3969 Ruckle St.
ZINK, Geo. A. (J'29), Engr., Charge Bearing Mfr., Allison Engrg. Co., Speedway.

JEFFERSONVILLE, Louisville Section
MYERS, Robt. D. ('21; '29), Power Engr., Colgate-Palmolive-Peet Co.

KOKOMO, Central Indiana Section
ARNETT, Robt. R. (J'27), Pur. Agent, Am. Dirigold Corp., 1142 S. Main St.; *for mail*, 115 N. Indiana Ave.
DeROO, Wm. C. ('30; '35), Ch. Draftsman, Delco Radio Div., Gen. Motors Corp., S. Home Ave.
LOMAN, John K. (J'35), Student Engr., Haynes Stellite Co.; *for mail*, 200 E. Walnut St.
MAGUIRE, Jas. H. ('22), Wks. Mgr., Haynes Stellite Co., S. Lindsay St.

LAFAYETTE, Central Indiana Section
ALT, Louis M. (J'30), M. E., Rostone, Inc., 308 Main St.
EMENS, Albert L. ('35), V. P. & Supt., Duncan Elec. Co.; *for mail*, 1002 Highland Ave.
ENGLISH, W. M. ('35), Supt. Motive Power, Chicago, Indianapolis & Louisville Ry., Lafayette; *for mail*, 1000 Northwestern Ave., W. Lafayette.
McALLISTER, Alfred J. ('26; '32; '35), Pres., Fairfield Mfg. Co.

SIETSMA, S. J. (J'35), 2d Lieut., 76th U. S. Field Artillery, Fort Warren, Wyo.; *home address*, R. R. 3, Lafayette, Ind.

LAFAYETTE, WEST. See WEST LAFAYETTE

LOGANSPORT, Central Indiana Section

GORDON, Bryon B. (A'17), Retired; Pa. R. R., Philadelphia, Pa.; *for mail*, 1530 Broadway, Logansport, Ind.

MARION, Central Indiana Section

GUINNUP, G. R. (J'32), 2620 S. Washington St.
WEBSTER, Lawrence B. ('10; '14; '18), 926 S. Washington St.

MICHIGAN CITY, St. Joseph Valley Section

GALE, Philroy C. ('24), Engr. in Charge, Dept. of Water Wks., 321 Franklin St.
LUNDY, Wm. L. ('20; '25; '35), 1215 Wabash St.
SOLLER, Arnold ('24; '31; '35), Ch. Engr., Hays Corp., E. 8th St.
SPRAGUE, Philip T. ('26), Gen. Mgr., Hays Corp., P. O. Box 299.

MISHAWAKA, St. Joseph Valley Section

CURRIER, Donald C. (J'27), 131 E. Mishawaka Ave.
KINDIG, A. J. (J'27), Testing Engr., Dodge Mfg. Corp.
SCHMIDT, Geo. W. ('36), Supt. Power, Ind. & Mich. Elec. Co.
VanDERHOEF, Geo. N. ('93; '98), Cons. Engr., Dodge Mfg. Corp.
WELCH, Kenneth B. (J'30), Indus. Engr., Mishawaka Rubber & Woolen Mfg. Co.; *for mail*, 319 N. Victoria St.
WENTWORTH, Starr S. (J'29), Engr., Dodge Mfg. Corp., 500 S. Union St.

MUNCIE, Central Indiana Section

BAKER, Chas. H., Jr. (J'36), Spec. Apprentice, Borg-Warner Div., Warner Gear Co., 1106 E. Seymour St.; *for mail*, Riverside & Briar Aves.
BATES, Rodman H. ('30), M. E., Ball-Muncie Eng. Co.; *for mail*, 817 W. Adams St.
BRIDGES, Donald A. (J'36), Student Engr., Owens-Ill. Glass Co.
SMITH, V. Weaver ('27), V. P., Broderick Co., Windsor St.

NEW ALBANY, Louisville Section

BLACKMAN, V. C. ('27), Ch. Engr., New Albany Mch. Mfg. Co., New Albany; *for mail*, Lincoln Heights, Jeffersonville.

NEWCASTLE, Central Indiana Section

BYERS, M. F. (J'35), 1808 Grand Ave.

NOBLESVILLE, Central Indiana Section

DROGUE, J. A. ('29), Plant Engr., Ball Bros. Co.; *for mail*, R. R. 5, Box 5.

NOTRE DAME, St. Joseph Valley Section

MacLEAN, J. A. (J'33), Instr. Aero. Engrg., Univ. of Notre Dame, Notre Dame; *for mail*, 530 N. Sunnyside Ave., S. Bend.

PRINCETON

YEAKEL, A. E. ('31; '35), M. E., Charge Power & Constr., Princeton Mining Co.

RICHMOND, Central Indiana Section

SCHAFER, Robt. A. ('26; '30), Engr., Charge Devel. & Exper., Natl. Automatic Tool Co.; *for mail*, 721 W. Main St.
STRADER, Lester E. (J'32), Draftsman, Automotive Gear Wks.; *for mail*, 304 N. 15th St.

RUSHVILLE, Central Indiana Section

REES, Myron D. (J'36), R. R. 7.

SOUTH BEND, St. Joseph Valley Section

ADAMS, Conrad R. ('14; '35), Pres., Gen. Mgr., Adams E. D. T., Inc., 1702 W. Washington Ave.
ANDRUS, Lucius B. ('19), c/o L. L. Andrus, 743 N. Scott St.
COBB, Elton T. ('30), Sales Engr., Bantam Ball Bearing Co.
FRANCE, Edgar G. ('19), Gen. Supt., Singer Mfg. Co.
FRAREY, Earle F. (J'36), Sales Engr., Bantam Ball Bearing Co., 3702 W. Sample; *for mail*, 1518 Lincoln Way, W.
GRUNWALD, Louis J. (J'33), 3635 Lincoln Way, W.
RODIN, Max B. (J'34), 310 S. Chapin St.
SPARROW, Stanwood W. ('18; '19; '23), Research Engr., Studebaker Corp; *for mail*, Morningside Club.
TOYNE, John W. ('23), Private Practice, 322-324 E. Colfax Ave.; *for mail*, 1017 DeMaude Ave.
WALLACE, Daniel S. ('30), Mgr. East. Factory, Sterling Pump Corp., 1838 S. Franklin St.
WILCOX, C. C. ('05; '15), Supt., Power Div., Studebaker Corp.

TERRE HAUTE, Central Indiana Section

BRADLEY, John A. (J'36), Lub. Sales Engr., Stand. Oil Co. of Ind., Stand. Oil Refinery, Whiting; *for mail*, 40 S. 24th St., Terre Haute.
GRAY, Henry C. (J'17), Instr., Mch. Design, Rose Poly. Inst.
KASAMEYER, Wm. E. (J'36), 333 Kent Ave.
KING, Kenneth J. ('24; '33), M. E., Charge New Constr. & Design, Commercial Solvents Corp., 1331 S. 1st St.
LARSEN, Arild F. (J'36), Indus. Engr., Prodexto Corp., 702 Sycamore Bldg.
PRENTICE, Donald B. ('13; '21; '24), Pres., Rose Poly. Inst.
SPAIN, Richard W. (J'36), Warehouse & Shipping Bonus Clerk, Owens-Ill. Glass Co.; *for mail*, 2325 Liberty Ave.
WISCHMEYER, Carl ('13; '22), Prof. M. E., Rose Poly. Inst.

VALPARAISO, Chicago Section

CUSHMAN, P. Allerton ('19; '24), Prof. M. E., Univ. of Valparaiso; *for mail*, 820 La Porte Ave.
KREITZMAN, Wm. F. (J'28), Maint. Engrg., Chicago Mica Co. & Fibroc Insulation Co., 408 Washington St., Valparaiso; *for mail*, 769 Pennsylvania St., Gary.

WABASH, Central Indiana Section

FRAME, C. C. ('32), Ch. Engr., G. M. Diehl Mch. Wks.; *for mail*, 166 Stitt St.

WARSAW, St. Joseph Valley Section

MORAN, Willard Royse (J'36), Student, Purdue Univ., W. Lafayette; *for mail*, 202 N. Detroit St., Warsaw.

WEST LAFAYETTE, Central Indiana Section

BAILEY, J. F. (J'35), 213 Harrison St.
BINDER, Raymond C. (J'30), Instr., Mch. Design, Sch. of M. E., Purdue Univ.
COLE, Arthur W. ('04; '11), Prof., Steam Engrg., Purdue Univ.
ERMENC, Jos. J. (J'34), Instr., Engrg. Drawing, Dept. Practical Mechanics, Purdue Univ.
FAIRMAN, Seibert ('31; '35), Assoc. Prof., Applied Mechanics, Purdue Univ.
GEIGER, John W. ('27; '33; '35), Asst. Prof. M. E., Purdue Univ.
GIRVIN, Harvey F. ('27), Asst. Prof. Applied Mechanics, Purdue Univ.; *for mail*, 618 Crestview Pl.
GRAY, Wm. ('36), Engr., Draft Gear Tests, Purdue Univ.; *for mail*, 479 Maple St.
HASKINS, Geo. W. ('21; '26; '35), Prof. Aero. Engrg., Purdue Univ.; *for mail*, 526 Hayes St.
HAWKINS, Geo. A. (J'30), Asst. Prof. M. E., Purdue Univ.; *for mail*, 304 W. Oak St.
HERRICK, Thos. J. (J'36), Grad. Asst. Applied Mechanics, Purdue Univ.; *for mail*, 275 Littleton St.
HOCKEMA, Frank C. ('22; '27), Asst. to Pres., Dir. Summer Sessions, Secy. Bd. Trustees, Purdue Univ.; *for mail*, 832 Main St.
HOFFMAN, James David ('94; '03), Prof., Head Dept., Director Labs., Practical Mechanics, also in charge Curriculum of Indus. Education, Purdue Univ.
JACKLIN, H. M. ('17; '25), Purdue Univ.
LINDLEY, Roy W. ('22; '25; '35), Asst. Prof. Practical Mechanics, Purdue Univ.; *for mail*, 114 De Hart St.
LUDY, Llewellyn V. ('05), Prof. Exper. Engrg., Purdue Univ.; *for mail*, 600 Russell St.
MESSERSMITH, Chas. W. (J'33), Asst. Prof. M. E., Purdue Univ.
MUNRO, Geo. W. ('12), Prof., Thermodynamics, Purdue Univ.; *for mail*, 202 Waldron St.
POTTER, Andrey A. ('12; F'36), President, '33; Dean, Schools of Engrg., Purdue Univ.
PRICE, Melvin ('05; '19), Asst. Prof. M. E., Charge Mch. Design, Purdue Univ., W. Lafayette; *for mail*, R. F. D. 5, Lafayette.
RUBENKOENIG, Harry ('17; '35), 1120 Northwestern Ave.
SAUERS, John A. ('17; '35), Asst. Prof. M. E., Purdue Univ.; *for mail*, 416 Dodge St.
SHEPARD, Geo. H. ('30), Prof. Indus. Engrg. & Mgmt., Purdue Univ.
SOLBERG, Harry L. ('21; '28; '32), Prof. M. E., Purdue Univ.
STOEVER, H. J. (J'35), Asst. Prof., M. E. Dept., Purdue Univ.
TURNER, Wm. Payson ('00; '08), Prof., Purdue Univ.
WALTERS, J. E. ('35), Prof., Dir. of Personnel, Purdue Univ., W. Lafayette; *for mail*, 1010 Elliott St., Lafayette.
YOUNG, Gilbert A. ('06), Head. Sch. of M. E., Purdue Univ., W. Lafayette; *for mail*, 739 Owen St., Lafayette.

WHITING, Chicago Section

BURROWS, Winston R. (J'30), Designing Engr., Stand. Oil Co. of Ind.; *for mail*, 1908 Superior Ave.
FOUST, Saml. A. (J'30), 1420 Lake Ave.
HUENGER, C. A. (J'31), Engr., Research Lab., Stand. Oil Co. of Ind., Front St.
MATHEWS, W. B. ('31), Engr., Stand. Oil Co. of Ind., Whiting, Ind.; *for mail*, 7156 East End Ave., Chicago, Ill.
MEYER, Royal L. ('25; '35), Supt. of Utilities, Stand. Oil Co. of Ind.; *for mail*, 1720 Cleveland Ave.
VAWTER, W. Dale (J'33), Devel. Dept., Lubricant Div., Sinclair Refining Co., E. Chicago; *for mail*, 1930 Davis Ave., Whiting.
WATTS, Geo. Wm. ('24; '35), Chief Engr., Standard Oil Co. of Ind., Front St., Whiting, Ind.; *for mail*, MacDonald Lane, Flossmoor, Ill.

IOWA

ADEL

STRAIGHT, H. R. ('31), Pres., Gen. Mgr., Adel Clay Products Co.

AMES, Tri-Cities Section

CLEGHORN, Mark P. ('14), Prof., Charge M. E. Dept., Iowa State College; *for mail*, 513 Ash Ave.
DAASCH, Harry L. ('35), Assoc. Prof. M. E., M. E. Dept., Iowa State College.
HUMMEL, Jesse G. ('21), Assoc. Prof. M. E., Iowa State College; *for mail*, 819—7th St.
LINDSEY, Mark F. (J'32), Gen. Mgr., Ames Mch. Shop, 820—2nd St.
MEEKER, Warren H. ('19), Prof. M. E. Dept., Iowa State College, Sta. A.
NORMAN, Roy A. ('21), Prof. M. E., Iowa State College; *for mail*, 715 Ridgewood Ave.
ROTHMEYER, Wm. R. (J'35), Graduate Asst., M. E. Dept., Iowa State College.
ROUDEBUSH, R. E. ('36), Assoc. Prof. M. E., Iowa State College.
VAN WINKLE, Geo. F., Jr. (J'34), Gen. Engrg. Dept., Iowa State College.

BETTENDORF, Tri-Cities Section

CANTWELL, John D., Jr. (J'32), Asst. Plant Engr., Micro-Westco, Inc. (Subsidiary of Bettendorf Co.), Bettendorf; *for mail*, 825 E. 14th St., Davenport.

BURLINGTON, Tri-Cities Section

PRUCHA, Victor L. (J'32), Y. M. C. A.

CEDAR RAPIDS, Tri-Cities Section

DeBRUIN, Edw. A. ('29; '35), Local Agent, Otis Elev. Co., 509 Higley Bldg.
DRABELLE, John M. ('19), M. & E. Engr., Iowa Elec. Light & Power Co., Security Bldg.; *for mail*, 2306 Hillcrest Dr.
FRIEDLINE, Jas. M. (J'35), 349—17th St., S. E.
JADRNICEK, Jas. Richard (J'35), 144—17th St., S. W.
OPPENHEIMER, Edwin A. ('28; '34; '35), Asst. M. M., Penick & Ford Ltd., Inc., 1st St. & 10th Ave.

CLINTON, Tri-Cities Section

MADSEN, Sern ('19), M. E., Curtis Cos., Inc.

DAVENPORT, Tri-Cities Section

HAFFORD, Willard B. ('31; '35), Prin. Engrg. Draftsman, Rock Island Arsenal, Rock Island, Ill.; *for mail*, 2025 Scott St., Davenport, Iowa.
HARGENS, Frank ('27; '32), Ord. Engr., Charge Design, Rock Island Arsenal, Rock Island, Ill.; *for mail*, 3029 Farman St., Davenport, Iowa.
HODGES, Kenneth R. (J'35), Under Engrg. Aid, Rock Island Arsenal, Rock Island, Ill.; *for mail*, 321 E. 10th St., Davenport, Iowa.
PLOEHN, John H. ('28), Supt., French & Hecht, Inc.
VOSS, Don R. (J'34), 2831 E. Pleasant St.
WILKINSON, Thos. L. ('94; '05; F'36), Vice-President, '24-'26; Cons. Engr., 2644 Telegraph Rd.
WILLIAMS, C. G. ('29), Tool Designer, Internatl. Harvester Co., Rock Island, Ill.; *for mail*, 310 E. 29th St., Davenport, Iowa.

DES MOINES

BORG, Elmer H. ('21; '26), Partner, Proudfoot, Rawson-Brooks & Borg, 815 Hubbell Bldg.
DANN, Willard J. (J'33), Asst. Supt., Des Moines Ry. Co., E. 4th & Maple Sts.
MORGAN, Dale R. (J'36), Mid-West Supply Co., 507 Grand Ave.
ORTMAN, Hadar ('30; '35), Dir. Oper., Meredith Publ. Co.
ROGERS, Wallace A. (J'33), Safety Engr. & Payroll Auditor, U. S. Fidelity & Guaranty Co., Equitable Bldg.; *for mail*, 4312 New York Ave.
SHAW, Burton Edw. ('29; '36), Research Chief, Charge Engrg. & Devel., Penn Elec. Switch Co., 2000 E. Walnut St.

DUBUQUE

LOETSCHER, Robt. F. (J'29), Asst. Supt., Farley & Loetscher Mfg. Co.
SCHMID, Fred G. ('32; '35), 1586 W. 3rd St.
WOODNORTH, Paul T. ('23; '35), Engr., Charge Power Plants, Interstate Power Co., 1000 Main St.

ELMA

BIWER, Anthony F. (J'27), Gen. Delivery.

GILMORE CITY

SPIES, F. Lewell (J'34).

IOWA CITY, Tri-Cities Section

BARNES, Ralph M. ('25; '29; '33), Prof. Indus. Engrg., College of Engrg., 107 Engrg. Bldg., State Univ. of Iowa.
CAYWOOD, Thos. G. ('30), Assoc. Prof. M. E., State Univ. of Iowa; *for mail*, 943 Iowa Ave.
CORNOG, Robt. (J'23), Grad. Student, Univ. of Calif., Berkeley, Calif.; *for mail*, 1155 E. Court St., Iowa City, Iowa.
CROFT, Huber O. ('20; '29; '32), Prof., Head M. E. Dept., College of Engrg., State Univ. of Iowa.
IRWIN, John B. (J'33), c/o United Air Lines.
KELLER, Geo. J. ('29), Assoc. Prof. M. E., State Univ. of Iowa; *for mail*, 221 S. Lucas St.
LUKSCH, Andreas (J'35), Asst. Research Engr., Iowa Inst. of Hyd. Research
MAVIS, F. T. ('33; '34), Prof., Assoc. Dir., Hydraulics Lab., State Univ. of Iowa.
POSEY, Cheslev J. (J'35), Asst. Prof., Mechanics & Hydraulics, Engineering Bldg., State Univ. of Iowa.
RUSS, John M. ('32), Assoc. Prof. Engrg. Drawing, State Univ. of Iowa.
THOREN, Theo. R. (J'36), Asst. Prof. M. E., Charge Lab., College of Engrg., State Univ. of Iowa.

MARSHALLTOWN, Tri-Cities Section

ATWATER, Wm. C. ('20), Factory Mgr., Lennox Furnace Co.
CASH, Arthur W. ('99), Apex Regulator Co.; *for mail*, 311 N. 1st St.

MASON CITY

MAYTHAM, Walter J. ('05), Cons. Engr., Northwestern States Portland Cement Co.; *for mail*, P. O. Box 268.

MUSCATINE, Tri-Cities Section

BOWEN, Leonard ('32), Engr., Barry Co., 4th & Poplar Sts.; *for mail*, 1216½ Smalley Ave.
STANLEY, C. Maxwell ('33; '35), Cons. Engr., Young & Stanley, 211 Iowa Ave.; *for mail*, 1106 Iowa Ave.

NEWTON

BOYD, Lee Roy (J'31), Ch. Engr., One Minute Washer Co.; *for mail*, 705 S. 4th Ave., W.

OTTUMWA

HILL, Geo. B. (J'36), Designer & Field Exper. Wk., Dain Mfg. Co., Vine St.; *for mail*, R. F. D. 2.

PERRY

COWAN, Frank ('21), M. E., Charge Maint., Perry Packing & Provision Co. of Iowa; *for mail*, 1916—4th St.

PRINCETON, Tri-Cities Section

SUITER, John R. (J'33), Engr., Design & Drafting, Williams White & Co., Moline, Ill.; *for mail*, Princeton, Iowa.

SIOUX CITY

NEAL, Geo. A. ('21; '35), V. P., Iowa Pub. Serv. Co.
ROCKLIN, I. J. (J'30), Gen. Mgr., Kool-Kleen Air Conditioning Co., E. 7th & Division St.; *for mail*, 3227 Jennings St.

WASHINGTON, Tri-Cities Section

KORF, Orval A. (J'35).

WATERLOO

BAILEY, Kenneth S. (J'32), Asst. in Fdy. Prod. Dept., John Deere Tractor Co.; *for mail*, 306½ Allen St.
HANSEN, Merlin (J'30), M. E., Charge Exper. Wk., John Deere Tractor Co.; *for mail*, 618 W. 3rd St.
KIESLING, Ted. S. (J'34), Asst. Foreman, John Deere Tractor Co.; *for mail*, 433 Pine St.
SEIPLE, J. Waldo (J'32), Jr. Engr. Exper. Eng. Dept., John Deere Tractor Co.; *for mail*, Rm. 406, Y. M. C. A.
YOUNG, J. Donald (J'29), Jr. Engr., Designer, John Deere Tractor Co.

WAYLAND, Tri-Cities Section

BERGH, Warren H. (J'28).

KANSAS

ARKANSAS CITY

BOTTOMLEY, Harold Francis (J'32), Ch. Research Chemist, Kanotex Refining Co.; *for mail*, 1000 South B St.

ATCHISON, Kansas City Section

DIVAL, Lawrence A. ('35; '35), Designing Engr., Loco. Finished Matl. Co., 3rd & Park Sts.; *for mail*, 310 Laramie.
TAYLOR, Gordon W. ('25; '32; '35), Serv. Engr., Loco. Finished Matl. Co., 3d & Park Sts.; *for mail*, 821½ Santa Fe.

AUGUSTA

BATES, Harvey C. (J'35), Asst. M. E., White Eagle Div., Socony-Vacuum Oil Co., Box 542; *for mail*, 337 Main St.
DEFOE, Jonathan C. (J'31), Box 233.
WALLACE, Wilfred N. (J'34), Route 2.

BELVIDERE

ROBBINS, Richard W. (A'23), Partner, Robbins Ranch.

CHANUTE

PETERSON, Milford K. (J'35), Model Laundry, Chanute, Kan.; *for mail*, 300—3rd Ave., Longmont, Colo.

CLAY CENTER

WOOD, Richard H. (J'32), Paving Engr., Kan. Highway Dept., 1413 Lincoln St., Clay Center; *for mail*, Cottonwood Falls.

COFFEYVILLE

BURRIS, Winston Durr (J'35), Draftsman, Oil Country Specialties Mfg. Co., Coffeyville, Kan.; *for mail*, 1921 E. 21st St., Tulsa, Okla.
RICHARDS, L. T. (J'29), Tech. Dept., Sinclair Refining Co.; *for mail*, 1005 W. 8th St.

FORT LEAVENWORTH, Kansas City Section

STONE, John R. ('19), M. E., Charge Maint., Industries, U. S. Penitentiary Annex.

GARDEN CITY

WINGET, R. W. (J'34), Engr. Charge Design, Wks. Progress Admin., Dodge City; *for mail*, Garden City.

GREAT BEND

BRINDLE, G. Ralph (J'35), Oiler, Main Engs., Natural Gas Pipeline Co. of Am., 20 N. Wacker Dr., Chicago, Ill.; *for mail*, Box 743, Great Bend, Kan.
ELDER, A. M. (J'34), Box 743.

HUTCHINSON

FOULDS, Jas. C. (J'35), 600 N. Monroe.
MOORE, J. Ewing (J'36), Training for Sales Engr., Oil Well Supply Co., Dallas, Tex.; *for mail*, 201 W. 9th Ave., Hutchinson, Kan.

KANSAS CITY, Kansas City Section

APPLEGATE, F. R. (J'35), Ch. Engr., Univ. of Kan. Hospital, Bell Memorial Hospital; *for mail*, 4012 Eaton.
BROOKS, Leo S. ('19; '35), M. E., Charge Maint., Sinclair Refining Co., 32nd & Kansas Ave.; *for mail*, 1426 S. 33rd St.
BRUZELIUS, Edw. M. (J'34), Draftsman, Columbian Steel Tank Co., 1509 W. 12th St., Kansas City, Mo.; *for mail*, 1140 Richmond Ave., Kansas City, Kan.
BURDGE, L. Richard (J'35), Procter & Gamble Co.; *for mail*, 2115 N. 13th St.
DARBY, I. Harry, Jr. ('21; '22; '30), Pres., Darby Corp., 921 N. 3rd St.
HART, Gaylord B. (J'35), Draftsman, Swift & Co.; *for mail*, 926 Cleveland Ave.
WILLIAMSON, Harry W. ('27), Turbine, Constr. Foreman, Gen. Elec. Co., 106 W. 14th St., Kansas City, Mo.; *for mail*, 4132 Eaton St., Kansas City, Kan.

LAWRENCE, Kansas City Section

HAY, Earl D. ('18; '20), Head Dept. M. E., School of Engineering, Univ. of Kan.
KING, John Aubrey ('23; '28; '31), Prof. Mech. Engrg., Univ. of Kan.
RUSSELL, Robt. H. (J'31), Slab Inspr., Constr. Engr., Kansas Highway Comm., Masonic Temple, Topeka; *for mail*, 728 Ohio St., Lawrence.
SLUSS, Alfred H. ('13), Prof. M. E., Univ. of Kan.; *for mail*, 827 Mississippi Ave.
TAIT, Ralph S. ('21; '24; '35), Assoc. Prof. M. E., Univ. of Kan.

LEBANON

FARRELL, J. M. ('33; '35).

MANHATTAN, Kansas City Section

ADAIR, Frank M. (J'36), Instr. Mch. Design, Dept. Mch. Design, Kan. State College.
BRAINARD, Boyd B. ('25; '34), Assoc. Prof. M. E., Kan. State College.
BURKES, L. C. (J'36), Research Asst. in M. E., Kan. State College; *for mail*, 1031 Kearney.
DURLAND, M. A. ('22; '30), Prof. Mch. Design, Asst. Dean of Engrg., Kan. State College.
HELANDER, Linn ('16; '24), Prof. & Head Dept. M. E., Kan. State College.
MACK, Albert J. ('22; '35), Assoc. Prof. M. E., Kan. State College.
NORMAN, Frederic J. (J'35), Dept. Mch. Design, Kan. State College.
PATTISON, Floyd ('19; '35), Home Study Serv., Kan. State College.
ROBERT, Jules H. (J'18), Assoc. Prof., Applied Mechanics, Kan. State College.
SEATON, R. A. ('13; '15; '16), Dean & Dir. of Engrg., Kan. State College.

OTTAWA, Kansas City Section

RANSOM, Willard G. ('17), Mem. Firm, Cook & Ransom, Ottawa; *for mail*, Homewood.

PARSONS

TOMLINSON, Chas. S. ('17; '25; '35), Neosho Plant Engr., Kan. Gas & Elec. Co.

PITTSBURG

HOLZER, Hiram A. ('21), Gen. Mgr., United Iron Wks. Co., 1st & Locust St.
THOMAS, Chris. Y. ('27; '35), M. E., Design & Maint., Pittsburg & Midway Coal Min. Co., 314 Natl. Bank Bldg.

SALINA

WARREN, Wm. V. (J'36), Engr., F. Wyatt Mfg. Co., 500 N. 5th St.; *for mail*, 214 N. 11th St.

TOPEKA, Kansas City Section

BOHNSTENGEL, Walter ('15; '24), Asst. Engr. Tests, Atchison, Topeka & Santa Fe Ry., Motive Power Bldg.
BUCK, Chas. P. ('19), Cons. Engr., 1530 College Ave.
CULBERTSON, Dan ('24; '26; '35), Test. Dept. Asst., Atchison, Topeka & Santa Fe Ry., Motive Power Bldg.; *for mail*, 1225 High Ave.
DUTTON, David (J'33), Water Conservation Engr., Water Conservation Div., Wks. Progress Admin., 912 Kansas Ave., Topeka; *for mail*, Burlingame.
ETTER, L. Fort (J'35), Test Dept. Asst., Atchison, Topeka & Santa Fe Ry., Motive Power Bldg.
LANCASTER, Kenneth G. (J'33), Draftsman, Kan. Highway Comm., 1263 Harrison St., Topeka; *for mail*, 312 S. Jefferson St., Junction City.
RUCKMAN, John H. ('21; '35), Cons. Engr., Rm. 544, New England Bldg.
RUFF, Henry (J'32), Constr. Dept., Southwest Bell Tel. Co., Topeka; *for mail*, 122 S. W. 4th St., Newton.
SULENTIC, S. A. ('15; '19), Pres., Ch. Engr., S. A. Sulentic Cons. Engr. Co., Inc., 224 New England Bldg.; *for mail*, 304 Leland St.
TILBURY, Sumner R. ('21), Fuel Supvr., East. Lines, Atchison, Topeka & Santa Fe Ry., Motive Power Bldg.
WATSON, J. W. (J'36), Watson Dairy Supply Co., 1032 Van Buren St.

WICHITA

BAUGH, Walter S. ('31; '35), Indus. Engr., Charge Power Sales, Kan. Gas & Elec. Co.
HENDERSON, Curtis L. ('23), V. P., Vickers Petroleum Co.
MICHAEL, John (J'35), Salesman, Natl. Supply Co.
ST. JOHN, Elbert D. ('31; '35), Asst. Supt. of Power, Kan. Gas & Elec. Co.
STILLWELL, Almeron W. (J'28), 317 S. Chautauqua Ave.

WINFIELD

BADEN, Martin W. ('29), Cons. Engr., Rm. 201, Baden Bldg.

YATES CENTER

FRANK, Austin C. (J'36), Concrete Inspr., U. S. Bur. of Reclamation, Ft. Sumner, New Mex.; *home address*, R. R. 1, Yates Center, Kan.

KENTUCKY

ASHLAND

BAILEY, Chas. Forrest (J'31), Draftsman, Am. Rolling Mill Co.; *for mail*, 818—19th St.
BROWN, T. C. (J'36), Drafting Instr., Ashland High Sch., 2129 Sellars St.
HUNTSBERGER, Russell C. ('20; '35), Supt., Mech. Maint., Am. Rolling Mill Co.; *for mail*, P. O. Box 173.
KORN, Norman L. (J'36), Oper., Ashland By-Product Coke Co.; *for mail*, 612 Gartrell St
PIERCE, Homer R. ('22; '24), Partner, Oil & Gas Recovery Co., 4422 Winchester Ave.; *for mail* 820 Windsor Court.
ROSS, Jas. W. (J'35), 2213 Bath Ave.

BARBOURVILLE

WILSON, Howard A. (J'34), 317 College St.

BARDSTOWN, Louisville Section

SAMUELS, T. W. (J'32), V. P., Gen. Mgr., T. W. Samuels Distillery, Inc., Deatsville; *home address*, Bardstown.

BOWLING GREEN

PORTER, Robt. E., Jr. (J'32), Ky.-Tenn. Light & Power Co.; *for mail*, 1228 College Street.
SCHWENDENER, H. G. ('29; '35), Pet Milk Co.

CATLETTSBURG

BARTRAM, Paul R. (J'34), M. E., Charge Cost Analysis, Carbide & Carbon Chems. Corp.; *for mail*, 1448 Center St.

COVINGTON, Cincinnati Section

KIESEWETTER, Frank H. (J'35), Asst. M. E., Thos. Emery's Sons, Inc., 2107 Carew Tower, Cincinnati, Ohio; *for mail*, 3919 Tracy Ave., Covington, Ky.

IRVINE

WOLF, H. Comer ('25; '31), Cons., Supervision, Research Engr., 110 Main St.

LAWRENCEBURG

RIPY, Ernest W., Jr. (J'36), Secy.-Supt., Engr., Ripy Bros.

LEXINGTON, Louisville Section

BUTCHER, Ira A. ('18; '24), Ch. Bldg. Inspr., Pub. Wks. Admin., P. O. Box 415.
BUTLER, Wm. E. (J'36), 273 E. Maxwell St.
CROPPER, Robt. O. (J'30), Sales Engr., Montgomery Ward & Co., 230 E. Main St.; *for mail*, 716 W. Maxwell St.
JETT, Carter C. ('02; '26), Prof. Mch. Design, Univ. of Ky.
O'BANNON, Lester S. ('22; '35), Prof., Heat-Power Engrg., Head Dept. M. E., Univ. of Ky.
PORTER, R. Clay ('36), Prof., College of Engrg., Univ. of Ky.

LOUISVILLE, Louisville Section

ASKEW, Miles A. ('21; '35), 311 Hillcrest Ave.
BEARD, Thos. W. (J'34), 2102 Saratoga Dr.
BOOKER, Wm. F., Jr. (J'34), Air Conditioning Dept., Peerless Mfg. Corp., 1400 W. Ormsby St.; *for mail*, 2323 Ransdell Ave.
BRIGMAN, Bennett M. ('23; F'36), Manager, '34-'37; Dean, Speed Scientific Sch., Univ. of Louisville.
CLO, Harry E. (J'34), 1359 S. 3rd St.
CREDO, Julius ('16; '35), V. P., Charge Sales, Louisville Drying Mchy. Co., 451 Baxter Ave.
CRULL, Harley Roy ('21), Mech. Inspr., Louisville & Nashville R. R. Co., 9th & Broadway.
CUMMINS, Norman W. ('18), V. P., Bade-Cummins Mfg. Co., 3401 Jewel St.; *for mail*, 2531 Cherokee Pkwy.
DREYER, Elmer J. ('16; '24), Sales Engr., Charge Territory Sales, Henry Vogt Mch. Co., 10th & Ormsby Sts.; *for mail*, 2304 Woodbourne Ave.
FENWICK, H. H. ('29), Assoc. Prof. Engrg. Drawing, Univ. of Louisville, 3rd & Shipp Sts.
FOWLER, Henry C., Jr. (J'30), Supt., Charge Bottle Cap Plant, Reynolds Metals Corp., 30th St. & Grand Ave.; *for mail*, 2711 Virginia Ave.
FURNAS, Vincent E., Jr. (J'35), 2141 Algonquin Pkwy.
GRUBBS, Lorin W. (J'35), Draftsman, James Clark, Jr. Elec. Co., 600 Bergman St.; *for mail*, 101 E. Kentucky.
HASELBERGER, Ray (J'35), Engr., Tractor Design, B. F. Avery & Sons Co., 1721 S. 7th St.
HEUSER, Henry V. (J'36), Inspr., Henry Vogt Mch. Co., 10th & Ormsby Sts.; *for mail*, 2101 Eastern Pkwy.
HUBLEY, Geo. W. ('20), Cons. & Advisory Engr., 403 Norton Bldg.
HURST, John F. ('22), Mech. Oper. Engr., Louisville Gas & Elec. Co., 311 W. Chestnut St.; *for mail*, 1288 Everett Ave.
JACKSON, Lewis R. ('33; '35), Salesman, Boiler Sales Dept., Henry Vogt Mch. Co.; *for mail*, 4520 S. 3rd St.
JACKSON, Percy ('04; '22), P. O. Box 14, Sta. E.
JOHNSON, J. Adolph ('16), Factory Mgr., Bade-Cummins Mfg. Co., 3401 Jewel St.; *for mail*, 405 S. Western Pkwy.
MEYER, John K. (J'36), Maint., Corhart Refractories Co., 16th & Lee Sts.
MURPHY, Howard C. ('32), V. P., Charge Sales, Am. Air Filter Co., Inc.
RABUCK, John A. ('24), M. E., Charge Design, Louisville & Nashville R. R. Co., 9th St.
ROBINSON, Goldsborough (A'31), Engr. & Pub. Accountant, 481 Starks Bldg.
ROMANN, John H. ('16), Gen. Mgr., Charge Wks., Ewald Iron Co., 224 N. Clay St.
SACK, Melvin (J'28), Ch. Engr., Heat Exchanger Dept., Henry Vogt Mch. Co., Inc.; *for mail*, 1044 Walter Ave.
SCOTT, Kenneth W. (J'36), Research Engr., Louisville Drying Mchy. Co., Inc., 451 Baxter Ave.; *for mail*, 305 Crescent Court.
SMITH, Arthur D., Jr. ('29; '35), Gen. Mgr., Mengel Body Co., P. O. Box 1049.
SPEED, Wm. Shallcross ('00; '04), Pres., Louisville Cement Co., 315 Guthrie St.
TROSPER, Ralph S. ('30; '35), Asst. Prof. M. E., M. E. Dept., Univ. of Louisville.
VANCE, Ledcreich S. ('23; '34), Asst. Engr., Louisville Water Co., 435—3rd St.
VIGUS, Cebron T. (J'32), 813 Packard Ave.
WELSH, John H. (J'35), 2120 Garland Ave.
WILSON, Jos. B. ('22), M. E., Louisville Water Co., 435 S. 3rd St.; *for mail*, 727 S. 4th Ave.
WORTH, Eugene B. (J'31), Engrg. Dept., Nengel Co.

MAYSVILLE

GREGG, Frank D. ('28; '34; '35), Ohio Valley Pulley Wks., Inc.

NATURAL BRIDGE

MARSHALL, Chas. C., Jr. (J'29), S. P. 2.

OWENSBORO

BENSON, D. C. (J'34), 302 E. 3rd St.

PADUCAH

INGLES, John S. (J'36), Spec. Apprentice, Mech. Dept., Ill. Cent. R. R., I. C. R. R. Shops, Paducah, Ky.; *for mail*, 6853 S. East End Ave., Chicago, Ill.
LEHNERER, Geo. (J'35), Spec. Apprentice in Company Shops, Ill. Cent. Sys.; *for mail*, Friedrich Apt.

SOUTH NEWPORT, Cincinnati Section

MORAN, W. L. (J'36), M. E. Charge Metal Inspc., Latonia Refining Corp. (Stand. Oil Co. of Ohio), P. O. Box 407, Covington; *for mail*, 118—16th St., S. Newport.

YANCEY

GUTHRIE, J. E. (J'36).

LOUISIANA

ALGIERS, New Orleans Section

RANTZ, Chas. F. ('16), Proprietor, Rantz Ice Factory, 222 Homer St.

BATON ROUGE, New Orleans Section

CLARK, Frank G. ('27), Gen. Foreman, Boilermakers & Welders Dept., Stand. Oil Co. of La.; *for mail*, 828 N. Boulevard.
CROSSAN, Thos. E. ('25; '35), Supt., Charge Opera., Maint., La. Steam Generating Corp.
GURNEY, Wm. B. ('24; '35; '35), La. Steam Generating Corp.
HOYT, Chas. P. (J'29), M. E., Charge Inspc. Div., Stand. Oil Co. of La., P. O. Drawer 551; *for mail*, P. O. Box 864.
JOHNSON, Hamilton ('27), Prof. M. E., La. State Univ., P. O. Box 134.
KERR, Eugene W. ('02; '08), Cons. Engr., 808 Lake Park.
LASSALLE, Leo Jos. ('21), Dean, College of Engrg., La. State Univ.
WATERFALL, Harry W. ('21), Prof. M. E. Dept., La. State Univ.; *for mail*, 2165 Wisteria St.
WEHE, Albert H. (J'29), Charge, Meter & Instru. Div., Stand. Oil Co. of La.; *for mail*, R. R. 1.
WHIPPLE, Wm. ('05; '16), Prof. Steam Engrg., La. State Univ., University Sta.
WHITAKER, Will Alton ('33; '35), Asst. Head Engrg. Dept., Stand. Oil Co. of La.
WILLIAMS, G. C. (J'34), Student Fellowship, La. State Univ.; *for mail*, 646 North St.

BREAUX BRIDGE, New Orleans Section

ST. GERMAIN, R. J. (J'34).

CROWLEY, New Orleans Section

ELBERSON, Leander P. ('16), Ch. Engr., La Irrigation & Mill Co.; *for mail*, Box 35.

DESTREHAN, New Orleans Section

DELAUNE, Herbert L. ('34; '35), Asst. Ch. Engr., Design & Maint., Pan-Am. Petroleum Corp. of La., Inc., Destrehan; *for mail*, 248 Dodge Ave., R. F. D. 2, New Orleans.

ELIZABETH, New Orleans Section

GLASGOW, C. L. ('04; '13), Calcasieu Sulphate Paper Co., Inc.

GRAMERCY, New Orleans Section

GROSS, Michael F. ('24), Ch. Engr., Colonial Sugars Co.; *for mail*, P. O. Box. 64.

HOUMA, New Orleans Section

DUPONT, Louis C. (J'34), 884 High St.

LAKE CHARLES, New Orleans Section

CHALKLEY, Henry G. ('08), Pres., Sweet Lake Land & Oil Co., Inc.
CHALKLEY, Henry G., Jr. ('31; '35), Engr. & Mgr., La. Canal Co., Inc.; *for mail*, 921 Iris St.
MENVILLE, Chas. A. (J'33), 411 Weber Bldg.

LAKE PROVIDENCE, Mid-Continent Section

HIDER, Geo. T. ('11; '16; '35), Partner, Hider Bros.

LAROSE, New Orleans Section

DAVIET, Claude E. (J'36), Box 96.

MONROE, Mid-Continent Section

BOARDMAN, Clark C. ('20), Mgr., Thermatomic Carbon Co., Sterlington; *home address*, 90 N. 2nd St., Monroe.
OAKLAND, Berny ('30), Mgr., La.-Del. Oil Properties, Inc., 601 Ouachita Natl. Bank Bldg.
PRENDERGAST, Jas. F. ('23; '30), 626 Rochelle
STRUBEN, Stephan J. ('26; '28), Ch. Engr. Charge Opera., Interstate Natural Gas Co., Bo 1482.

NEW ORLEANS, New Orleans Sectio

ABELL, H. C. ('00; '02), Life Member; V. P. Elec. Bond & Share Co., 701 St. Louis St.
BECK, Geo. D. ('27; '30), Erec. Supt., Worthington Pump & Mchy. Corp., 2331 Constance St
BECK, Jas. D. ('06), Cons. & M. E., 2331 Constance St.
BENDER, Chas. A., Jr. (J'31), Lub. Engr., Gul Refining Co., P. O. Box 400; *for mail*, 172 Marengo St.
BENEDICT, Loyal C. ('19; '26; '35), Ch. Regiona Engr., Wks. Progress Admin., 1734 New Yor Ave., Washington, D. C.; *for mail*, 907 Cana Bank Bldg., New Orleans, La.
BRODIE, J. S. ('30), Supt. Maint., Fed. Barg Lines, 211 Camp St.
BURNS, Homer S. ('11), Asst. V. P., Engrg., Free port Sulphur Co., 1804 American Bank Bldg.
BURWELL, R. T. ('01), Ch. Engr., Mgr., Hartfor Steam Boiler Ins. & Inspc. Co., 1128 Hiberni Bank Bldg.
COLEMAN, Harry F. ('23; '25; '35), Dept. Mgr Grinnell Co., Inc., 1422 Carondelet Bldg.
CRAWFORD, Chas. C. ('06; '16; '18), V. P A. M. Lockett & Co., Ltd., 505 Queen Crescent Bldg.
CRONVICH, Jas. A. (J'36), 4708 Banks St.
CUCULLU, Lionel J. (J'36), Power Engr., Ne Orleans Pub. Serv., Inc., 317 Baronne St.
DAVIS, Arthur Chas. ('17; '22), Constr. Engr Charge Design, Constr., Am. Sugar Refinin Co., 7417 N. Peters St., Arabi; *for mail*, 79 Willow St., New Orleans.
EARL, Ralph ('16; '24; '26), Partner, Earl Engr Co., Whitney Bank Bldg.
FLOWER, T. Robt. (J'30), Engr., Charge Desig H. P. Gas, New Orleans Pub. Serv., Inc., 31 Baronne St.
FROST, Frank G. ('13), Gen. Supt., Elec. Dept New Orleans Pub. Serv., Inc., 317 Baronne S
FURCHGOTT, A. C., Jr. (J'33), Dispatcher, Eas Air Lines, Shushan Airport.
GRANT, Arthur A. ('19), Cons. Engr., 1543 Can Bank Bldg.
GREGORY, Wm. Benj. ('95; '03), Manager, '1 19; Vice-President, '20-'21; '31-'33; Pr Exper. Engrg., Tulane Univ.

HADDEN, Cal. F. ('21), Secy., Treas., Stand. Supply & Hardware Co., P. O. Drawer 620.
HAMMETT, Geo. R. ('20; '29; '35), Asst. Sales Mgr., A. M. Lockett & Co., Ltd., 505 Queen & Crescent Bldg.
HUEY, John S. ('34), Cons. Engr., 915 Maritime Bldg.
IRELAND, Mark L. ('02; '13), Col., U. S. A.; Commanding Officer, New Orleans Quartermaster Depot, 4400 Dauphine St.
IVENS, Edmund M. ('08; '17), 4 Dunleith Court.
JAHNCKE, Commodore Ernest Lee ('04; '29), Vice-President, '29-'31; Boston Club.
JOHNSON, Warren (A'04), Pres., Gen. Mgr., Johnson Iron Wks. Dry Dock & Shipbldg. Co., Box 840; *for mail*, 2031 St. Charles Ave.
KOFFSKEY, Geo. ('23), Retired; 730 Clouett St.
LEININGER, Jos. E. (J'32), Air Conditioning Engr., Gulf Engrg. Co., Inc., 916 S. Peters St.; *for mail*, 920 Music St.
LOCKETT, Andrew M. ('00), Pres., A. M. Lockett & Co., Ltd., Queen & Crescent Bldg.
LOCKETT, Robt. P. ('31; '35), Mgr., New Orleans Sales, A. M. Lockett & Co., Ltd., 505 Queen & Crescent Bldg.; *for mail*, 2130 Palmer Ave.
LUEHRMANN, Hugh ('31), Salesman, A. M. Lockett & Co., Ltd., 505 Queen & Crescent Bldg.
MANNEY, Chas. J. (J'34), M. E., Instr., Tulane Univ.; *for mail*, 1932 Broadway.
MARICE, P. J. (J'33), 3816 Carondelet St.
MAYER, John King (J'30), Instr., Engrg. Labs., Tulane Univ.; *for mail*, 1738 Carrollton Ave.
McLELLAN, Edw. A. (J'36), Salesman & Office Estimator, A. M. Lockett & Co., Ltd., 5th Floor, Queen & Crescent Bldg.
MERRITT, P. G., Jr. (J'30), Assoc. Engr., John S. Huey, Maritime Bldg.
MICHEL, Michael Patrick H. (J'34), Sales Engr., Calmes Engrg. Co., 215 Carondelet Bldg.; *for mail*, 323 Alix St.
MILLER, Richard H. ('36), 4472 Venus St.
MOODY, Howard N. ('20; '35), Cons. Engr., 823 Perdido St.
MULLER, Richard F. ('21; '29; '35), Sales Engr., Allis-Chalmers Mfg. Co., 1124 Canal Bank Bldg.
NELSON, Bernard Stanley ('10; '17; '22), Ch. Engr., A. M. Lockett & Co., Ltd., 501 Queen & Crescent Bldg.
NELSON, Waldemar S. (J'36), Asst. Timekeeper & Draftsman, A. M. Lockett & Co., 501 Queen & Crescent Bldg.; *for mail*, 7319 Panola St.
PARKERSON, William ('30; '35), 339 Carondelet St.
PATERSON, A. B. ('20), Pres., New Orleans Pub. Serv., Inc., 317 Baronne St.
PEIRCE, Carroll J., Jr. (J'31), Asst. Office Engr., Sewerage & Water Bd. of New Orleans, 526 Carondelet St.
PENDER, W. R. ('20; '35), c/o A. M. Lockett & Co., Ltd., Queen & Crescent Bldg.
REED, Francis T. ('21; '25; '35), Staff Asst. to Pres., Stand. Oil Co. of La., 2134 St. Charles Ave.
REMANJON, A. deR. (J'34), United Fruit Co.; *for mail*, 1511 Pine St.
REYNICK, Henry F. ('26), Mgr., Reynick Co., 402 Jackson Ave.; *for mail*; 7933 Willow St.
RICKETTS, G. B. S. (J'34), 5703 Willow St.
ROBERT, Jas. M. ('20), Dean, College of Engrg., Tulane Univ.
ROBERTS, Thos. H. ('18), M. E., 1530 N. Broad St.
ROEHM, Jack M. (J'34), 1315 Louisiana Ave.
SAUNDERS, Wm. H. ('18; '24; '35), Pres., Internatl. Lubricant Corp., P. O. Box 390.
SCHWARTZ, S. B. (J'36), Cons. Engr., 1050 Constance St.
STANCLIFF, Arthur D. ('12; '19; '35), Lone Star Cement Corp., 1120 Hibernia Bank Bldg.
STEARNS, Ellis J., Jr. (J'34), 1208 Pine St.
STEWART, David W. ('22; '35), Ch. M. E., Charge of Plant, New Orleans Pub. Serv., Inc., 317 Baronne St.
TODD, Jas. M. ('22; '29), Manager, '33-'36; Vice-President, '36-'38; Cons. M. E., E. E., 315-317 Balter Bldg.
WAIT, Wm. B. (J'14), Plant Engr., Am. Sugar Refining Co., 132 N. Peters St.; *for mail*, 2303 State St.
WIER, John B., Jr. ('20), Wks. Supt., S. Cotton Oil Co., P. O. Box 360.
WIGGIN, Chas., Jr. (J'27), Secy., Treas., Sales Engr., Walter Castanedo, Inc., 329 Balter Bldg.
WINSHIP, Walter E. ('08), 608 Common St.
WYLER, Chas. J. ('21; '31), Asst. Ch. Engr., A. M. Lockett & Co., Ltd., 501 Queen & Crescent Bldg.

PLAQUEMINE, New Orleans Section

NADLER, Robt. A. (J'30), V. P., Charge Engrg., Nadler Foundry & Mch. Co., Inc.; *for mail*, 711 Eden St.

PORT SULPHUR, New Orleans Section

BLACKSTONE, F. B. (J'29).
ROSS, Jas. H. ('21; '30).

SHREVEPORT, Mid-Continent Section

BLANCHARD, A. G. ('36), Mgr., Inferno Co., Box 1080.
FITZGERALD, Wm. E. (J'35), Engr., Fitzgerald Plumbing & Htg. Co., Inc., 939-41 Louisiana Ave.; *for mail*, 210 Vine St.
LYON, Wm. H. (J'29), Jr. Engr., Ark. Natural Gas Corp.
McGREW, F. Ray (A'23), Pres., Stand. Pipe Line Co., Inc., Box 1107.
McINTOSH, Sidney A. ('25; '32), V. P., Gen. Mgr., Sto-Mac Engrg. Corp., 603 Giddens Lane; *for mail*, 219 Willkinson St.
McLEAN, Harvey D. (J'36), Supt., Rodessa Oil & Refining Corp., Box 38.
MOORE, Jerome T. (J'29), M. E., Southwest. Gas & Elec. Co., 430 Travis St.
STEWART, M. G. (A'23), Pres., Mgr., Pelican Well Tool & Supply Co.; *for mail*, Box 276.
WHELESS, Eakin L. ('25; '35), 1st Natl. Bk. Bldg.

STERLINGTON, Mid-Continent Section

PAGE, Henry W. (J'29), Test. Engr., La. Power & Light Co.
PHILLIPS, R. L. ('34), Plant Supt., La. Power & Light Co.; *for mail*, Sterlington.

SULPHUR

RICKETTS, Raymond (J'36), Maint. Engr., Union Sulphur Co.

VIVIAN, Mid-Continent Section

CALDWELL, John A. (J'33).

WINNFIELD, New Orleans Section

DALE, David N. (J'34), Gulf Research & Devel. Co.; *for mail*, P. O. Box 111.

MAINE

AUGUSTA

BURR, Wilfred C. (J'28), Jr. Engr., Charge Design & Constr., Me. State Highway Comm., Augusta; *for mail*, Mattawamkeag.

BANGOR

DIXON, Leon S. ('21), Cons. Engr., Gen. P. O. Box 301, New York, N. Y.; *for mail*, E. Hampden, Bangor, Me.

BATH

BATES, Howard C. (J'33), Asst. to Mch. Foreman, Bath Iron Wks. Corp., Union St.; *for mail*, 15 Snow Park.
DAVIS, Frank R. ('33; '34; '35), Lieut., U. S. N., Asst. Inspr. Mchy., Bath Iron Wks. Corp.

BELFAST

MORTIMER, Jas. D. ('20), 710 N. 12th Blvd., St. Louis, Mo.; *home address*, R. D. 4, Belfast, Me.

BERWICK

WEBBER, Laurance E. (J'34), Mech. Inspr., Sales Registers, U. P. M. Kidder Press Co., Inc., Locust St., Dover, N. H.; *for mail*, 53 Rochester St., Berwick, Me.

BIDDEFORD

BLAKE, Edmund E. ('13), Ch. Engr., Saco-Lowell Shops, Biddeford; *for mail*, 75 North St., Saco.
HALL, Alfred E. B. ('19; '28), Draftsman, Saco-Lowell Shops, Biddeford; *for mail*, 94 Beach St., Saco.
SMITH, Harry L. ('28), Mech. Supt., Pepperell Mfg. Co., Biddeford; *for mail*, 76 Harrison Ave., Saco.
TRINDER, Fred'k J. ('13), Dir., Vocation Education, Saco-Lowell Shops, Biddeford; *for mail*, 47 High St., Saco.
ZALKIND, Benj. J. (J'29), Textile Engr., Exper. Wk., Saco-Lowell Shops, Smith St.; *for mail*, 67 Birch St.

BUCKSPORT

BEARCE, Geo. D. ('21; '25); Gen. Mgr., Me. Seabord Paper Co.

CUMBERLAND MILLS

STEVENS, Howard W. (J'34), 78 Lamb St.
TERRY, Killey E. ('14), Ch. Engr., Charge Plant Maint. & Constr., S. D. Warren Co.

EASTPORT

PERKINS, Ralph Linwood, Jr. (J'36), Draftsman, U. S. Engrg. Dept.

LEWISTON

BENNETT, Morris C. (J'35), Asst. in Cost Dept., W. S. Libbey Co., Lewiston; *for mail*, 72 Summer St., Auburn.
LIBBEY, W. Scott ('31; '35), Treas., Gen. Mgr., W. S. Libbey Co.

McGUCKIAN, Jos. (J'31), Accountant, Cost-Control Wk., W. S. Libbey Co.; *for mail*, 709 Main St.

MADAWASKA

WADE, Edw. A. ('30; '35), Combustion Engr., Fraser Cos., Ltd., Edmundston, N. B., Can.; *for mail*, Box 508, Madawaska, Me.

MADISON

ADAMS, Floyd W. ('26), 19 Park St.
WESTON, Robt. T. (J'32), Foreman, Weston Homestead Dairy Farm; *for mail*, Box 1076.
PRAGEMAN, Irving H. ('26; '35), Asst. Prof. M. E., Univ. of Maine; *for mail*, Box 173.

ORONO

SWEETSER, W. J. ('13), Prof. M. E., Univ. of Maine; *for mail*, 109 Main St.
YOUNG, Stanley Paul (J'34), 83 Park St.

PORTLAND

CHAPLIN, M. P. ('18; '35), Treas., Chaplin Corp., 123 Westbrook, S. Portland; *for mail*, P. O. Box 1474, Portland.
ELLIOTT, Newton R. ('17; '35), Draftsman, City Engrs. Office, Municipal Bldg., 25 Cottage Rd., S. Portland; *for mail*, 41 Lowell St., S. Portland.
HILL, Wm. ('83; '89), Retired; 535 Stevens Ave.
MANSFIELD, R. Carleton (J'32), Meterman, Cumberland Co. Power & Light Corp.; *for mail*, 302 Brackett St.
MERRILL, Carle J. ('16), Treas. & Mgr., C. J. Merrill, Inc., 54 St. John St.
SHAW, M. M. ('16; '22), 404 Commercial St.

ROCKLAND

GREENLAW, Alfred L. (J'35), 136 Middle St.

RUMFORD

AHARA, Edw. V. ('25; '36), Asst. Engr., Oxford Paper Co.

SACO

ALBRECHT, Geo. F. ('31), Ch. Draftsman, Saco-Lowell Shops, Smith St., Biddeford; *for mail*, 78 Beach St., Saco.

SCARBORO

VOORHEES, Gardner T. ('00), Route 1, Scarboro, Me.; *for mail*, Engrs. Club, 32 W. 40th St., New York, N. Y.

SKOWHEGAN

MARBLE, Gerald C. ('18; '25; '35), Hyd. Constr., Elliott & Marble.

STONINGTON

McGUIRE, Thos. G. (J'34), Engr., Deer Island Granite Corp.; for mail, Box 12.

WATERVILLE

REDDEN, Clarence Albert (J'27), Engr., Hollingsworth & Whitney Co.; *for mail*, 9 Getchell St.

YORK VILLAGE

RIVOIRA, Edilio J. (J'34), Box 245.

MARYLAND

ABERDEEN PROVING GROUND, Baltimore Section

ADAMSON, Keith ('14; '29), Lieut.-Col., Ord. Dept., U. S. A., Aberdeen Proving Ground.
CARTEN, Leo. A. (J'34), Jr. Engr., Guns & Carriages, Aberdeen Proving Ground; *for mail*, Aberdeen.
WOODS, Saml. H. ('15; '21), Automotive Engr., Aberdeen Proving Ground.

ANNAPOLIS, Baltimore Section

HOBBS, Elmer E. ('20; '35), Foreman, Power Plant, U. S. Naval Academy.
JOACHIM, Wm. F. ('29), Cons. Diesel Engr., U. S. Naval Engrg. Exper. Sta.
JOHNSON, Theodore W. ('00; '13), Life Member; Capt., U. S. N. (Retired); 11 Acton St.
KIEFER, Paul Jas. ('15; '20), Prof. M. E., Head Dept., U. S. Naval Postgraduate Sch.
SWEENEY, Ronald J. ('29; '35; '35), Asst. M. E., Testing, U. S. Naval Engrg. Exper. Sta., Annapolis; *for mail*, Arnolds.
TREAT, Burnett F. ('26; '35), Assoc. M. E., U. S. Naval Engrg. Exper. Sta.; *for mail*, R. F. D. 1.

BALTIMORE, Baltimore Section

ALLEN, Jos. ('28; '35), Mgr., Otis Elev. Co., 120 S. Paca St.; *for mail*, 5514 S. Bend Rd., Mt. Washington.
ALLNER, F. A. ('22), Gen. Supt., Pa. Water & Power Co., Lexington Bldg.

ANGELL, Eugene Nathan (J'33), College Apprentice, Prod. Dept., Gen. Chem. Co., 2000 Race St.; *for mail,* 5305 Laurelton Ave.
AUSTIN, Wm. S. ('02; '06), Cons. Engr., 800 Maryland Trust Bldg.
BAKER, John R. ('23; '35), Asst. to Gen. Supt., Pa. Water & Power Co., 1611 Lexington Bldg.
BENJES, Edward M. (J'34), Draftsman, Revere Copper & Brass, Inc., Danville & Baylis Sts.; *for mail,* 610 E. Pratt St.
BERRYMAN, H. O. ('21; '35), Natl. Can Co., 811 S. Wolfe St.
BLACK, Winfield S. ('14; '35), Plant Engr., Am. Sugar Refining Co., Key Highway E.
BODIE, Belin V. (J'34), 302 E. 28th St.
BOETCHER, Hans N. ('31; '35), Asst. to Supt. of Steam Stas., Consltd. Gas Elec. Light & Power Co., Lexington Bldg.; *for mail,* 4711 E. Lane, Roland Park.
BOLGIANO, Clarence P. ('20; '27), Prof., 4604 Springdale Ave.
BOLGIANO, Gilbert F. ('24; '35), Valuation Engr., Bartlett Hayward Co.
BOND, Francis M. ('09; '15), Asst. Dir., Indus. Bur. of Baltimore, 2303 Baltimore Trust Bldg.; *for mail,* 5811 Pimlico Rd.
BOWEN, Wm. V. ('24; '28; '35), Engr., Charge Design, Pa. Water & Power Co., 1611 Lexington Bldg.
BOYNTON, Wentworth Derries (J'36), 800 St. Georges Rd., Roland Park.
BRILLHART, S. Edw. ('23; '31), Engr., West. Elec. Co., Inc., Baltimore; *for mail,* Lincoln Ave., Lutherville.
BULLOCK, Jos. B. (J'36), Asst. Testman, Steam Stas. Dept., Consltd. Gas Elec. Light & Power Co., Westport Steam Sta.; *for mail,* 1940 Breitwert Ave.
BURBANK, Wm. Everett (J'29), Inside Salesman, Natl. Casket Co., Lombard & Front Sts.; *for mail,* 6002 Ready Ave.
BURRILL, Harold G. ('18; '21; '28), 810 Keyser Bldg.; *for mail,* 2219 Roslyn Ave.
CARLSRUD, Reidar ('27; '35), Devel. Engr., Crosse & Blackwell Co., 6801 Eastern Ave.
CHATARD, Wm. M. ('03; '09), 213 Keyser Bldg.
CHISHOLM, C. R. ('34), M. M., Md. Dry Dock Co., Box 101, South Sta.; *for mail,* 3712 Spaulding Ave.
CHRISTIE, A. G. ('07; '16; F'36), Manager, '22-'25; Vice-President, '25-'27; Prof. M. E., Johns Hopkins Univ.
COLLIER, Wm. I. ('30), Mech., Htg., Ventilating Engr., W. I. Collier & Co., 522 Park Ave.
CONN, Thos. D. ('16; '19; '35), Asst. Harbor Engr., Bur. of Harbors, City of Baltimore, Broadway Pier; *for mail,* 3505 Lynchester Rd.
COOK, Henry R., Jr. ('21), Gen. Supt., Gas Oper. Div., Consltd. Gas Elec. Light & Power Co., Lexington Bldg.
CROMWELL, Oliver C. ('14), Asst. to Ch. M. P. & Equip., Baltimore & Ohio R. R. Co., Baltimore & Charles St.
CUTLER, Jas. B. ('17; '24), M. E., Pa. Water & Power Co., Lexington Bldg.
DALSHEIMER, Hugo (A'30), V. P., Plant Supt., Lord Baltimore Press, 1500 Greenmount Ave.; *for mail,* 7402 Park Heights Ave.
DANNETTEL, Raymond C. ('24; '35), Asst. to Supt. Steam Stas., Consltd. Gas Elec. Light & Power Co.; *for mail,* 3100 Howard Park Ave.
DELANO, Raymond P., Jr. ('31), Serv. Mgr., Carl Spoerer's Sons Co., 901 S. Carey St.; *for mail,* 800 N. Hilton St.
DENNIS, B. W. ('11; '18), 606 W. North Ave.
DERINGER, B. W., Jr. (J'36), Engrg. Dept., Am. Hammered Piston Ring Co., Bush & Hamburg Sts.; *for mail,* Plaza Apts., Park Ave. & Wilson St.
EGGERT, Erwin H. ('29; '36), M. E., Proctor & Gamble Co., Baltimore; *for mail,* 517 Park Ave., Towson.
ELDER, John D. ('28), Ch. Engr., Crown Cork & Seal Co., Inc., Highlandtown, Baltimore; *for mail,* Montrose Ave., Catonsville.
EMERSON, Col. Geo. H. ('17), Ch. M. P. & Equip., Baltimore & Ohio R. R. Co.
FAST, Gustave ('15; '35), Pres., Gen. Mgr., Fast Bearing Co., Hampden Ave. & 23rd St.
FORMAN, A. Haslup (J'32), Foreman, Charge Insp. & Packing, Carr-Lowrey Glass Co., Westport St.; *for mail,* 18 W. 25th St.
FRANKENA, August (J'35), Am. Sugar Refining Co., Key Highway E.
FREEMAN, Carroll L. (J'23), Indus. Power Rep., Consltd. Gas Elec. Light & Power Co., 408 Lexington Bldg.
GAIL, Geo. Wm. ('17; '21; '35), Pres. & Treas., G. W. Gail, Inc., 1213 Court Square Bldg.
GALLOWAY, Walter S. ('29), Pur. Agt., Baltimore & Ohio R. R. Co., Baltimore; *for mail,* Gibson Island, Pasadena.
GOMPF, Arthur M. (J'34), Stand. Oil Co. of N. J., 1423 S. Clinton St.; *for mail,* 2724 St. Paul St.
GONTER, Raymond J. (J'36), 1003 McDonough St.
GREEN, Robert J. (J'35), 638 Regester Ave., Stoneleigh.
HANHART, Henry Ernest, Jr. (J'33), Gen. Foreman, Charge Maint., Bethlehem Steel Co., Sparrows Point; *for mail,* 626 Bartlett Ave., Baltimore.
HANSON, Karl P. (J'34), Instr. in M. E., Johns Hopkins Univ.
HARTMAN, Lawrence R. (J'36), Engrg. Student Course, Consltd. Gas Elec. Light & Power Co., Monument St. Sta.; *for mail,* 3630 Kimble Rd.
HENDERSON, Everett B. (J'36), 3103 Weaver Ave.
HERBERT, Leslie E. (J'30), Engr., Chem. Warfare Serv., Edgewood Arsenal, Edgewood; *for mail,* 806 E. North Ave., Baltimore.
HIGGINS, Nathan B. ('26), Ch. Engr., Pa. Water & Power Co., 1611 Lexington Bldg.
HILDENBRAND, Chas. F. (J'35), Engr., Elec. Meter Dept., Consltd. Gas Elec. Light & Power Co., Lexington Bldg.; *for mail,* 3406 Oakenshaw Pl.
HINE, Russell C. ('18; '35), Asst. to Supt. Steam Stas., Consltd. Gas Elec. Light & Power Co., Westport; *for mail,* 2740 Guilford Ave.
HOFSTETTER, E. T. Cruse ('27; '30; '35), Asst. to Supt., Steam Generation Gas Plant, Consltd. Gas Elec. Light & Power Co., Fort Ave & Leadenhall St.; *for mail,* 1815 E. 31st St.
HOLTZMAN, Paul T. (J'36), Prod. Dept., Rustless Iron & Steel Corp., Edison Highway; *for mail,* 1108 N. Eutaw St.
HOWARD, John Eager (J'23), Dist. Mgr., B. F. Sturtevant Co., 10 E. Mulberry St.
JOHNSON, Fred V. ('20), Devel. Engr., 5703 Berkeley Ave.
JUSTICE, Wm. C. (J'35), Heating Engr., May Oil Burner Corp., Maryland Ave. & Oliver St.; *for mail,* 520 Tunbridge Rd.
KEEN, Geo. W. ('24; '34), Ch. Engr., Westport Plant, Consltd. Gas Elec. Light & Power Co., Baltimore; *for mail,* 4 Mayfield Ave., Halethorpe.
KENT, Lawrason R. ('25; '35; '35), 3405 Fairview Ave.
KIRWAN, Kenneth K., Jr. (J'35), Constr. Supt., Raymond Concrete Pile Co., 140 Cedar St., New York, N. Y.; *for mail,* 209 Chancery Rd., Baltimore, Md.
KNIGHT, Jas. E. (J'36), Draftsman, Glenn L. Martin Co.; *for mail,* 15 Flagship Rd., Dundalk.
KOUWENHOVEN, Frank W. ('17; '25; '35), Assoc. in M. E., Johns Hopkins Univ., Homewood.
KRAMER, Conrad (J'33), 2213 Whittier Ave.
LASTNER, Chas. Andrew (J'31), Draftsman, Safe Harbor Water Power Corp., 1600 Lexington Bldg.; *for mail,* 2046 Harlem Ave.
LEDNUM, J. Maynard ('17; '22; '29), Ch. Engr., Silica Gel Corp., Baltimore Trust Bldg.; *for mail,* 4203 Linkwood Rd.
LEILICH, Capt. Frank T. ('19; '28), Cons. Engr., 810 Court Sq. Bldg.; *for mail,* 2611 Chelsea Terrace.
LOGAN, Lloyd ('16; '25), Assoc. Prof. Gas Engrg., Johns Hopkins Univ., Rm. 207, Maryland Hall.
LOIZEAUX, Alfred S. ('15), E. E., Consltd. Gas Elec. Light & Power Co., Lexington St.
LUBBERT, Geo. L. ('16; '35), Elec. & Mech. Engr., Manhattan & Merville Aves.
MacCLARENCE, John (J'36), Asst. Test Man, Consltd. Gas Elec. Light & Power Co.; *for mail,* 424 Winston Ave.
MALONE, John F. ('30), Dist. Steam Rep., Consltd. Gas Elec. Light & Power Co., 485 Lexington Bldg.; *for mail,* 4001 Maine Ave.
MELE, Thos. W. (J'36), Engr., Charge Engrg. Stands., Fisher Body Co., Broening Highway; *for mail,* 3211 Alameda Blvd.
MERRIAM, Carroll F. ('16; '21; '24), Gen. Engrs., Pa. Water & Power Co., 1611 Lexington Bldg.
MEYER, Carl W. (J'29), Dist. Rep., Johns-Manville Sales Corp., Baltimore Trust Bldg.
MIDGETTE, E. L. (J'35), Instr., Johns Hopkins Univ.
MORGAN, I. N. R. (J'33), Asst. Engr., Engr. of Mfr. Div., West. Elec. Co., Inc., 2500 Broening Highway.
MORTON, Allen W. ('28), Gen. Mgr., Am. Hammered Piston Ring Co., Bush & Hamburg Sts.
MUNROE, Edwards K. ('20), M. E., Navy Dept., Bur. Yards & Docks, 3434 Navy Bldg., Washington, D. C.; *home address,* 5924 Bellona Ave., Baltimore, Md.
NORRIS, Alexander M. ('12; '21), V. P., Chatard & Norris, Inc., 218 Water St.
NORRIS, J. Byrd, Jr. ('15; '25), Sales Mgr., Ellicott Mch. Corp., 1611 Bush St.
NORTON, Arthur W. ('23), Secy., Treas., Johnson Bros. Co., 227 N. Howard St.; *for mail,* 5502 Wayne Ave.
PALMER, J. Hambleton (J'35), Training Course, Bethlehem Steel Co., Sparrows Point; *for mail,* 5508 Normandy Pl., Baltimore.
PASSANO, Edw. B. ('12), Pres., Waverly Press, Inc., Mt. Royal & Guilford Aves.
PASSANO, William M. ('27; '35), Treas. & Gen. Mgr., Waverly Press, Inc., Mt. Royal & Guilford Aves.
PENNIMAN, Abbott L., Jr. ('15; '21; '32), Supt. Steam Sta., Consltd. Gas Elec. Light & Power Co.; *for mail,* 3409 Greenway.
PERKINS, Walter F. ('29), V. P., Bartlett Hayward Div., Koppers Co.
PFAFF, Geo. C. ('19; '26), Asst. Ch. Engr., Bartlett Hayward Co.; *for mail,* 3023 Presstman St.
POSEY, Jas. ('07; '19; '34), Cons. Engr., 1755 Baltimore Trust Bldg.
POWELL, Paul R. ('15; '23), Designing Engr., Crown Cork & Seal Co., Guilford Ave.; *for mail,* 205 Stony Run Lane.
PROCTOR, Wm. E. (A'22), Pres. Proctor Engrg. Co., 28 S. Gay St.
QUARLES, Frank W. ('21; '35), Test Engr., Consltd. Gas Elec. Light & Power Co.; *for mail,* 4040 W. Hayward Ave.
RACH, J. Louis W. ('19; '35), M. E., Design, Bartlett Hayward Co., Scott St.; *for mail,* 1947 E. 31st St.
SCHLUDERBERG, C. C. ('22; '35), Designer, Bartlett Hayward Co.; *for mail,* 5920 Burgess Ave., Hamilton.
SCHMEISSER, Ernest G. ('17), 828 Munsey Bldg.; *for mail,* Charles Apts.
SEXTON, Saml. Budd, 3rd (J'34), Asst., Administrative Dept., Safe Harbor Water Power Corp., 1611 Lexington Bldg.; *for mail,* 902 W. Belvedere Ave.
SHREEVE, C. Alfred, Jr. (J'36), Asst. in Devel. Lab., U. S. Indus. Alcohol Co., Curtis Bay, Baltimore; *for mail,* 200 W. Pennsylvania Ave., Towson.
SMALLWOOD, Julian C. ('13), Assoc. Prof. of M. E., & Cons. Engrg., Johns Hopkins Univ., Homewood.
SMITH, L. G. ('23; '27; '35), Asst. to Gen. Supt., Consltd. Gas Elec. Light & Power Co.; *for mail,* 106 W. 28th St.
STEELE, Maurice G. ('26), Tech. Advisor, Revere Copper & Brass, Inc., 1301 Wicomico St.
STEVENS, Wm. R. ('29), Asst. Engr., Mech. & Elec. Valuation, Baltimore & Ohio R. R. Co., 1105 B. & O. Bldg.
STRAUS, Wm. R. ('13; '23), Bur. of Mech. Elec. Serv., Municipal Office Bldg.
TAYLOR, A. W. ('33), Combustion Engr., Stand. Oil Co. of N. J., Boston & Eaton St.; *for mail,* 4319 Arabia Ave.
THOMAS, Ralph L. ('26), Gen. Supt., Pa. Water & Power Co., Lexington Bldg.; *for mail,* 803 St. George's Rd.
TURNER, Lee ('34; '35), Dist. Sales Mgr., Internatl. Paper Products, Inc., 220 E. 42nd St., New York, N. Y.; *for mail,* 4100 N. Charles St., Baltimore, Md.
UNDERHILL, Henry L. ('15), Ch. Engr., Bartlett Hayward Co.
VARNEY, Wm. W. ('92), Pat. Solicitor, Atty.-at-Law; *for mail,* 6017 Bellona Ave.
VIESSMAN, Warren ('23; '28; '30), M. E., Design, Div. of Procurement, Treasury Dept., Washington, D. C.; *for mail,* 2205 Lake Ave., Baltimore, Md.
VON BEHREN, J. Norvell (J'25), Engr., Charge Design & Constr., Tainton Products, Ltd., 3100 Elm Ave.
WALDEN, Robt. R. ('21; '30; '35), Asst. Engr., Engrg. Dept., U. S. Indus. Alcohol Co.; *for mail,* 4008 Hamilton Ave.
WHITELEY, S. M. ('34), Cons. Engr., 908 Baltimore Life Bldg.
WHITMAN, Ezra B. ('24), Partner, Whitman, Requardt & Smith, W. Biddle St. at Charles.
WHITSITT, W. B. ('18), M. E., Baltimore & Ohio R. R. Co.
WILLIAMS, N. Stafford (J'30), Asst. Engr., Rubber Covered Wire Dept., Point Breeze Works, West. Elec. Co., Inc.; *for mail,* 3104 Montebello Terrace.
WILMOTH, Harold E. (J'31), Jr. Tech. Asst., Consltd. Gas Elec. Light & Power Co., Fort Ave.; *for mail,* 5303 Old Frederick Rd., Woodlawn P. O.
WOOD, Fred'k W. ('13), Cons. Engr., 2429 Keyworth Ave.
WOODWARD, Hiram W. ('16; '23; '35), Managing & Indus. Engr., 30 S. Calvert St.
WORTHINGTON, John A. ('35; '35), Mgr. Indus. Sales, Am. Hammered Piston Ring Co., Baltimore; *for mail,* Berwick Ave., Ruxton.
ZIMMERMAN, Richard E. ('27; '35), M. E. Struc. Designer, Gas & Elec. Co., Madison St.; *for mail,* 2710 Auchentoroly Terrace.

BEL AIR, Baltimore Section

ADDICKS, Lawrence ('11), Cons. Engr.

BENSON, Baltimore Section

SHRIVER, Harry T. (J'93), Benson, Harford Co.

CAMBRIDGE

WHITHAM, Jay M. ('83), Cons. Engr., 134 Mill St.

CEDARHURST

CASSELL, Chas. W. (J'29), Asst. Plant Engr., Congoleum-Nairn, Inc., Cedarhurst; *for mail,* 2 Anchor St., Westminster.
HAUSMAN, Sidney (J'23), Plant Supt., Congoleum-Nairn, Inc.

CHEVY CHASE, Washington, D. C., Section

AITCHISON, Clyde S. (J'20), 109 W. Underwood St.
BECKWITH, Ward S. (J'26), 402 W. Thornapple St.

COCKEYSVILLE, Baltimore Section

PEIRCE, Wm. H. ('87), Cockeysville, Baltimore Co.

COLLEGE PARK, Washington, D. C., Section

BAILEY, Wayland S. ('30; '30; '35), Asst. Prof. M. E., Univ. of Md.; *for mail,* Box 55, College Park.
NESBIT, Jos. N. G. ('11), Prof. M. E., Univ. of Md., College Park; *for mail,* Riverdale.

CONOWINGO, Baltimore Section

TAYLOR, Roger ('17; '27), Plant Supt., Susquehanna Elec. Co.

CUMBERLAND

BROWE, Ernest L. ('36), Power Engr., Celanese Corp. of Am., Cumberland, Md.; *for mail,* Whitney Point, N. Y.
LYONS, Bartholomew J. ('29; '35), Ch. Estimate Engr., Celanese Corp. of Am.; *for mail,* 704 Gephart Dr.
McKAIG, W. Wallace (A'14), V. P. & Gen. Mgr., Cumberland Steel Co.
MOSLER, Arthur R., Jr. (J'34), Indus. Engr., Celanese Corp. of Am.; *for mail,* 815 Braddock Rd.
ROBERTS, Saml. B. ('19; '25; '29), Asst. to Ch. Engr., Celanese Corp. of Am.; *for mail,* P. O. Box 223.

CURTIS BAY, Baltimore Section

THOMPSON, Eustis H. ('22), M. E., Charge Power Survey, U. S. Indus. Alcohol Co., Curtis Bay; *for mail,* 1301 St. Paul St., Baltimore.

DUNDALK, Baltimore Section

BISSER, A. Steven (J'34), 17 Flagship Rd.
RYAN, Edmund J. (J'35), Asst. Plant Supt., Charge Maint., Baltimore Pure Rye Distilling Co., Sollers Pt. Rd., Dundalk; *for mail,* 3120 Weaver Ave., Baltimore.

FROSTBURG

ALEXANDER, Ralph I. ('19; '23; '35), M. E., Celanese Corp. of Am., Cumberland; *for mail,* 181 E. Main St., Frostburg.

GLENARM, Baltimore Section

METZ, Ellwood A. ('18; '35), V. P., Gen. Mgr., F. X. Hooper Co., Inc.; *for mail,* Glenarm, Baltimore County.

HAGERSTOWN

VEDDER, W. O. ('24; '34), Ch. Engr., Dust Collecting Div., Pangborn Corp.; *for mail,* 1200 Oak Hill Ave.

LANHAM, Washington, D. C., Section

CARLSSON, Carl A. V. ('05), Retired, Whitfield Rd.

MT. SAVAGE

MOHLER, Robt. Claude ('31; '35), Supt. Motive Power, Cumberland & Pa. R. R. Co.

PORT DEPOSIT, Baltimore Section

WEST, G. Alvin ('17; '24; '35), Mch. & Chem. Plant Designer, Chem. Warfare Serv., U. S. Army, Edgewood Arsenal; *for mail,* Port Deposit.

ST. MICHAELS

REGISTER, Albert L. ('22), Hidden Harbor.

SPARROWS POINT, Baltimore Section

ANDERSON, Robt. C. (J'35), Inspr., Bethlehem Steel Co.; *for mail,* 903 D St.
CLARKE, C. Edwin (J'12), Asst. Gen. Mgr., Bethlehem Steel Co.; *for mail,* 520 B St.
COFFIN, Louis F. ('26), Supt., Mech. Dept., Bethlehem Steel Co.; *for mail,* 820 C St.
COOK, Fred C. (J'34), Pipe Galvanizer, Bethlehem Steel Co., Sparrows Point; *for mail,* 3408 Auchentoroly Terrace, Baltimore.
DAVIS, Edmund C. (J'33), Engr., Fuel Dept., Bethlehem Steel Co.; *for mail,* 612 B St.
DONOVAN, Daniel Edw. ('22; '35), Port Engr., Ore Steamship Corp., Sparrows Point; *for mail,* 3032 Dunleer Rd., Dundalk.
GOULD, L. J. (J'28), Asst. Supt., Bethlehem Steel Co.; *for mail,* 717 C St.
HILL, Wm. P. (J'33), Test Engr., Bethlehem Steel Co., Sparrows Point; *for mail,* 3219 McShane Way.
KNABE, Fred Smith (J'35), M. E., Charge Loco. Boilerwater Treatment, Bethlehem Steel Co.; *for mail,* 712 F St.
STEFFEY, J. Grason, Jr. (J'35), Bethlehem Steel Co.; *for mail,* 506 C St.
WILKE, Wm. P., III (J'34), Expediter, Cold Strip Prod., Bethlehem Steel Co.; *for mail,* 915 E St.

TAKOMA PARK, Washington, D. C. Section

DANNETTELL, Harry W. (J'35), 105 Cedar Ave.

TOWSON, Baltimore Section

MICHEL, Rudolph ('17; '25; '35), Asst. Mar. Engr., Bur. of Engrg., Navy Dept., Washington, D. C.; *for mail,* 603 San Pierre Rd., Towson, Md.

WILLIAMSPORT

GORDON, Eugene ('24; '33; '35), Supt. Steam Sta., Potomac Edison Co., Williamsport; *for mail,* 528 Summit Ave., Hagerstown.

MASSACHUSETTS

ALLERTON, Boston Section

RIVETT, Edward ('04), Box 259.

ALLSTON, Boston Section

MATUKAS, John J. (J'35), Spec. Apprentice, Boston & Maine R. R., N. Billerica; *for mail,* Suite 10, 248 Warren St., Allston.
NUTT, Harold V. (J'32), Instr., U. S. Diesel Corp., 89 Brighton Ave.

AMESBURY, Boston Section

BOWER, Edw. I. (J'36), 4½ Collins Ave.
JOHNSON, Leonard Ware (J'36), Draftsman, Bailey Mfg. Co., Water St.

ANDOVER, Boston Section

OLSON, Ernest W. (J'29), M. E., Charge Maint., Tiyer Rubber Co., Railroad St.; *for mail,* Andover St.
WARE, Chas. L. ('20), Supvr. Engr., Am. Woolen Co., 225—4th Ave., New York, N. Y.; *for mail,* 21 Williams St., Andover, Mass.

ARLINGTON, Boston Section

LARKIN, Wm. Harrison, Jr. ('04), Cons. Engr., 10 Robin Hood Rd.
RICKWOOD, Rowland L. ('22; '28), 25 Norfolk Rd.
WARD, Ierdell C. (J'34), 83 Bow St.

ASHLAND, Boston Section

CAMPBELL, Jas. R. ('32), Engr., Charge Diesel Eng. Design, Lombard Governor.

ATHOL, Worcester Section

BUTLER, Harry M. ('19), M. E., Union Twist Drill Co.; *for mail,* 95 Highland Ave.
CUMMINGS, Richard A. (J'34), 115 Drury Ave.
GORTON, John C. ('97; '99), M. E., Union Twist Drill Co.; *for mail,* 115 Liberty St.
HORIGAN, John H. ('21; '35), Secy., Union Twist Drill Co.; *for mail,* 159 Drury Ave.
MACKAY, Simon ('17), V. P., Charge Mfg., Maint., Union Twist Drill Co.; *for mail,* 387 School St.
SIMPSON, Robert J. O. ('06), Supt. M. E., L. S. Starett & Co.; *for mail,* 129 Union St.
WILCOX, Jos. S. ('13; '16; '21), Treas., Wilcox Co.

ATTLEBORO, Providence Section

COLE, Robert W. (J'36), Student Apprentice, Spencer Thermostat Co., 34 Forest St.; *for mail,* 214 A Park St.
MOSSBERG, Frank ('95), Pres., Mossberg Pressed Steel Corp.
OLSON, Robt. V. ('29; '35), V. P., Charge Sales, Mossberg Pressed Steel Corp., West St.
WING, Raymond Francis (J'35), 22 Jefferson St.

AUBURNDALE, Boston Section

PARKER, Francis A. ('29; '35), 20 Fern St.

BARRE, Worcester Section

McQUESTON, Francis W. (J'34), Draftsman, Chas. G. Allen Co.; *for mail,* Broad St.

BARROWSVILLE, Providence Section

GRAHAM, Clarence T. ('24; '35), Supt. & Buyer, Defiance Bleachery, Barrows St.

BASS RIVER, Boston Section

DAVIS, Chas. H. ('90), Pres., Various Corporations; Trustee, Various Estates.

BELMONT, Boston Section

ADAMS, Comfort A. ('17), Cons. Engr., Edw. G. Budd Mfg. Co., 25th & Hunting Park Ave., Philadelphia, Pa.; *home address,* 115 Leonard St., Belmont, Mass.
CHENEY, Nathan ('06), Res. Engr., Inspr., Pub. Wks. Admin., Washington, D. C.; *for mail,* 242 Payson Rd., Belmont, Mass.
DOLE, Myron W. ('33), 105 Stults Rd.
KLAFSTAD, Erling ('31; '35), Ch. Engr., Charge Devel., Crosby Steam Gage & Valve Co., 10 Roland St., Boston; *for mail,* 2 Brookside Ave., Belmont.
MOULTROP, Irving E. ('02; F'36), Manager, '08-'11; Vice-President, '12-'14; Cons. Engr., 28 Adams St.
SPENCE, Robert A. (J'35), Grad. Student, Harvard Grad. Sch. of Engrg., Pierce Hall, Cambridge; *for mail,* 37 Davis Rd., Belmont.

BEVERLY, Boston Section

CROSS, Garrett P. S. ('13), Exper. Dept., United Shoe Mchy. Corp., Elliott St.; *for mail,* 6 Clifton Ave.
EASTMAN, Fred C. ('28), Mch. Designer, Exper. Dept., United Shoe Mchy. Corp., Elliot St., Beverly; *for mail,* 9 Pickwick Rd., Marblehead.
KIMBALL, Henry B. (J'35), Designing Engr., United Shoe Mchy. Corp., Elliot St., Beverly; *for mail,* 75 Banks Rd., Swampscott.

BOSTON, Boston Section

ALBRIDGE, Kenneth P. ('17; '35), Salesman, Frigidaire Sales Corp. of New Eng., 23 Blandford St., Boston; *for mail,* 162 N. Main St., Sharon.
ALEXANDER, Wm. T. (J'30), Asst. Prof. Indus. Engrg., Northeast. Univ., 316 Huntington Ave.
ARCHIBALD, Francis L. (J'30), Steam Testman, Edison Elec. Illum. Co. of Boston, 39 Boylston St., Boston; *for mail,* 90 South St., Medford.
ARONSON, Mark (J'19), Dir., Charge Devel. & Sales, Aronson Research Labs., 88 Tremont St.
ATKINSON, Kerr ('30), Engr., Jackson & Moreland, Engrs., 31 St. James Ave.
AUSTIN, Wm. Henry (J'33), Student, Mass. Inst. of Tech., Cambridge; *for mail,* 45 Child St., Hyde Park, Boston.
AVIS, Saml. W. ('18), Cons. Engr. on Design Devel. & Equip., Reece Button Hole Mch. Co., 502 Harrison Ave.
BAKER, Roland H. ('18; '26; '32), Pres., Roland H. Baker Co., 10 State St.
BALKAN, Saml. A. (J'36), Training Course, Fellows Gear Shaper Co., Springfield, Vt.; *for mail,* 70 Howland St., Roxbury, Boston, Mass.
BARNARD, Clayton H. (J'36), Bailey Meter Co., 60 Batterymarch St.
BAYLISS, Wm. Arthur ('29), Ch. Inspr., Hartford Steam Boiler Inspc. & Ins. Co., 87 Kilby St.
BEAVEN, H. Edgar ('20; '26; '35), Engr., Am. Mutual Liability Ins. Co., 142 Berkeley St., Boston; *for mail,* 756 Watertown St., W. Newton.
BECK, Edw. Stanley ('28; '35), Secy., Business Mgr., New Eng. Aircraft Sch., Boston Airport, E. Boston; *for mail,* 18 Field Rd., Arlington.
BEERS, Ralph E. (J'35), 117 Marlboro St.
BELL, Walter R. (J'26), Sales Engr., Ingersoll-Rand Co., 285 Columbus Ave.
BENNETT, Clinton Wendell ('22; '35), Partner, Cooley & Marvin Co., 140 Federal St., Boston; *for mail,* 10 Everell Rd., Winchester.
BENOIT, A. W. ('21), Assoc., Chas. T. Main, Inc., 201 Devonshire St.
BENTLEY, Oliver D. H. ('10), Mgr. & Engr., B. F. Sturtevant Co., Damon St., Hyde Park.
BERRY, Francis E. (A'24), Pres., Treas., F. E. Berry, Jr. & Co., Inc., 203 Ipswich St.
BIXBY, Walter ('07; '26), M. E., Pat. Atty., 1 Mt. Pleasant Terrace, Roxbury.
BJURLING, Elmer R. (J'30), 887 Adams St.
BLAIR, Ernest L. ('19; '26; '35), Engr., Mech. Div., Stone & Webster Engrg. Corp., 49 Federal St., Boston; *for mail,* 108 Willow Ave., Wollaston.
BRADY, John J. ('18; '35), Sales Mgr., Combustion Engrg. Co., Inc., 80 Federal St.
BRIDGES, Luther W. ('15), M. E., Chas. H. Tenney & Co., 38 Chauncy St., Boston; *for mail,* 273 Union Ave., Framingham.
BROWN, Arthur L. ('17; '25), Dir., Factory Mutual Labs., Associated Factory Mutual Fire Ins. Cos., 184 High St.; *for mail,* 49 Hemenway St.

BROWN, H. J. ('16), Cons. Engr., 35 Doane St.
BROWN, Lawrence W. (J'34), Installer, Am. Dist. Telegraph Co., 60 State St., Boston; *for mail*, 14 Liberty Ave., W. Somerville.
BRYAN, Marcus K. ('16; '35), Steam Engr., Chas. T. Main, Inc., 201 Devonshire St.
CARGILL, Walter N. ('12), Sales Agt., Steam Apparatus & Accessories, 185 Devonshire St., Boston; *for mail*, 7 Woodland St., Arlington.
CARHART, Frank M. ('28), Partner, Jackson & Moreland, Park Sq. Bldg.
CARTY, Maurice W. ('21), M. E., Stone & Webster, Inc., 49 Federal St., Boston; *for mail*, 64 Allerton Rd., Newton Centre.
CHANDLER, Leonard D. ('18), Mem. Firm, Rideout, Chandler & Joyce, 130 Broad St.
CLARK, Frank S. ('09; '12), Cons. Engr., Stone & Webster Engrg. Corp., 49 Federal St.
CLARK, Myron H. ('13), Myron H. Clark & Associates, 80 Federal St., Boston; *for mail*, Davis Rd., Bedford.
COHEN, A. S. ('15; '35), M. E., Mgr., N. L. C. Engrg. & Equip. Co., 101 Tremont St.
COLBY, Harold L. ('26), M. E., Sales Dept., Mason-Neilan Regulator Co., 1190 Adams St., Boston; *for mail*, 71 Waldeck Rd., E. Milton.
COLLINS, John A. ('24), Secy., Mutual Boiler Ins. Co. of Boston, 185 Franklin St.
CONNELL, Paul C. (J'29), Engr., House Htg. Dept., Boston Consltd. Gas Co., 100 Arlington St.; *for mail*, 79 Moraine St., Jamaica Plain.
COOK, Wm. H., Jr. (J'34), Mass. Inst. of Tech. Dormitories.
CRABB, Gordon Henry ('30; '35), Mfg. Supt., No. Indus. Chem. Co., 11 Elkins St., S. Boston; *for mail*, 9 Weyandke St., Dorchester.
CURTIS, Ralph E. ('88; '01), 15 Allenwood St., W. Roxbury.
CUSHING, Ralph A. ('13), Asst. Supt., Pneumatic Scales Corp. Ltd., Norfolk Downs; *for mail*, 145 Pond St., S. Weymouth.
DAVID, Marshall S. (J'29), Cadet Engr., Boston Consltd. Gas Co., 100 Arlington St., Boston; *for mail*, 154 Harvard St., Newtonville.
DAVIDSON, Archer (A'07), Cent. Sta. Engr., Westinghouse Elec. & Mfg. Co., 10 High St., Boston; *for mail*, 154 Warren St., Newton Centre.
DEAN, F. W. ('83), Vice-President, '95-'97; Cons. Engr., 89 Broad St.
DEAN, H. K. ('27; '35), Sales Engr., Babcock & Wilcox Co., 49 Federal St.
DENLEY, Alfred N. ('20), Engr., Chas. T. Main, Inc., 201 Devonshire St., Boston; *for mail*, 29 Maxwell Rd., Winchester.
DERRY, Gardner C. ('36), V. P., B. F. Sturtevant Co., Damon St., Hyde Park, Boston; *for mail*, 82 N. Main St., Sharon.
DEVRIES, R. P. ('17; '35), Ch. Engr., Revere Sugar Refinery, 333 Medford St., Charlestown.
DORIOT, Georges F. ('23; '35), Prof. Indus. Mgmt., Harvard Business Sch., Soldiers Field.
DOWDING, Leonard E. ('24; '35), M. E., Durable Wire Rope Co., 51 Sleeper St.
DUFFY, Thos. J. (J'32), Safety Engr., Plant Inspc., Liberty Mutual Ins. Co., 10 E. 40th St., New York, N. Y.; *for mail*, 31 St. James Ave., Boston, Mass.
DUNNELL, Wm. W., Jr. ('27; '30; '33), Ch. Engr., Reece Button Hole Mch. Co., 502 Harrison Ave.; *for mail*, 86 Myrtle St.
DURGIN, Clyde M. ('22; '28), Ch. Draftsman, New Eng. Power Engrg. & Serv. Corp., 89 Broad St., Boston; *for mail*, 115 Everett St., Wollaston.
EATON, Geo. C. (J'25), Head, Mech. Prod. Engrg. Div., Edison Elec. Illum. Co. of Boston, 39 Boylston St.
EDDY, Harrison P., Jr. ('27), Partner, Metcalf & Eddy, 1300 Statler Bldg.
EDWARDS, Wm. Wesley ('13; '17; '35), Prof. Heat Engrg., Wentworth Inst., Huntington Ave., Boston; *for mail*, 16 Regent St., W. Newton.
ELDREDGE, A. H. ('94), Cons. Engr., North Packing & Provision Co., P. O. Box 5247, Boston; *for mail*, 76 Laurel St., Melrose.
ELL, Carl S. ('21), Dean & V. P., Northeast. Univ., 316 Huntington Ave.
ELLIS, Frederic R. ('27), Sales Engr., Buerkel & Co., Inc., 18-24 Union Park St.; *for mail*, 131 Beacon St., Hyde Park.
ENGLE, Melvin D. ('22; '31), Supt., Stationary Engrg. Dept., Edison Elec. Illum. Co. of Boston, 39 Boylston St., Boston; *for mail*, 33 Allen Rd., Winchester.
EVERETT, Elmer H. (J'36), Teacher, Lincoln Tech. Inst., 23 Belvidere St.
FARRELL, Fred'k L. ('13; '21; '35), Dist. Mgr., Combustion Engrg. Co., Inc., 80 Federal St., Boston; *for mail*, 537 California St., Newtonville.
FAVORITE, R. J. ('21; '31), Engr., M. E. Div., Stone & Webster Engrg. Corp., 49 Federal St., Boston; *for mail*, 667 Chestnut St., Waban.
FERRETTI, Alfred J. ('17; '24; '30), Assoc. Prof. M. E., Northeast. Univ., 316 Huntington Ave.
FISHER, Russell T. ('23; '35), Secy., Natl. Assn. of Cotton Mfrs., 80 Federal St.
FLETCHER, F. Richmond (A'21), Partner, McKinsey, Wellington & Co., 110 State St.
FLINNER, A. O. ('29; '35; '35), 324 Commonwealth.
FORBES, Robt. T. ('21), New Eng. Agt., Green Fuel Economizer Co., Peabody Engrg. Corp., Alco Products, Inc., De Wolf Furnace Corp., 201 Devonshire St., Boston; *for mail*, 448 Woodward St., Waban.
FOSTER, Willard H. (J'33), Asst. Prod. Mgr., Boston Envelope Co., 315 Centre St., Jamaica Plain; *for mail*, 15 Landseer St., W. Roxbury.
FREEMAN, Fred'k S. ('15), Supt. Power, Boston Elev. Ry. Co., 536 Harrison Ave.
FREEMAN, Myron F. (J'25), Mem. Firm, Arthur L. Nelson, Engrs., Park Sq. Bldg., 31 St. James Ave.; *for mail*, 23 Potomac St., W. Roxbury.
FRENCH, Edw. V. ('05), Pres., Arkwright Mutual Fire Ins. Co., 185 Franklin St.
GILBERT, Eugene C. (J'35), Inspr., Charge Installations & Tests, Submarine Signal Co., 160 State St., Boston; *for mail*, 20 Harrison St., Brookline.
GLEASON, Gilbert H. ('06; '12), Partner, Gilbert, Howe, Gleason & Co., 25 Huntington Ave.,
GLENNIE, Geo. W. ('25; '31; '35), Underwriter of Boiler & Mchy. Ins., Employers Liability Assurance Corp., 110 Milk St., Boston; *for mail*, 21 Wolcott Ave., Andover.
GLOSSA, Aloysius J. (A'19), Prod. Engr., Edison Elec. Illum. Co. of Boston, 39 Boylston St., Boston; *for mail*, 214 Washington St., Malden.
GLYNN, John F., Jr. (J'32), 133 Eustis St.
GOLDING, Harold B. ('29; '35), Internatl. Equip. Co., 352 Western Ave., Brighton, Boston; *for mail*, 48 Massachusetts Ave., Dedham.
GOODNOW, John M. (J'23), Pres., Hardware Products Co., 103 Richmond St., Boston; *for mail*, Corner Stetson Rd., Greenbush.
GOVE, Lewis P. ('21; '35), Ch. Inspc. Engr., Charge Field Wk., Mutual Boiler Ins. Co. of Boston, 185 Franklin St., Boston; *for mail*, Outlook Rd., Wakefield.
GRAHAM, E. H. (J'35), Student Engr., Gen. Sales, B. F. Sturtevant Co., Hyde Park.
GREENE, Chas. Edw. ('20; '23), M. E., E. E., Metcalf & Eddy, Engrs., 1300 Statler Bldg.
GREENE, Elliott ('21), Mgr., Cochrane Steam Spec. Co., Rm. 1015, 80 Federal St.
GREENWOOD, T. T. ('17; '35), Pat. Atty., 40 Court St.
GRUBMAN, Lieut. M. T. ('23; '31), Apprentice School Officer, Navy Yard.
GUNBY, Frank M. ('15), Assoc., Chas. T. Main, Inc., 201 Devonshire St., Boston; *for mail*, 12 Manchester Rd., Winchester.
HADAWAY, John B. ('12), Cons. Engr., Exper. Dept., United Shoe Mchy. Corp., 140 Federal St., Boston; *for mail*, 21 Bay View Dr., Swampscott.
HALE, Robt. S. ('94; '97; '99), Pres., Scoutland, Inc., Carby St., Westwood; *for mail*, 939 Boylston St., Boston.
HALL, Walter A. ('11), Cons. Engr., 89 Boylston St.
HALLOCK, Fletcher D. ('22), Mgr., Engrg. Div., Westinghouse Elec. & Mfg. Co., 10 High St.
HARTWELL, Hiram B. (J'03), M. E., Crosby Steam Gage & Valve Co., Roland St., Charlestown, Boston; *for mail*, 9 Townsend St., Waltham.
HARVEY, J. C. ('18), Propr., J. C. Harvey Co., 971-975 Commonwealth Ave.
HASTINGS, Raymond G. ('30), Engr., Jackson & Moreland, Engrs., 31 St. James Ave.
HATFIELD, Harvey C. ('21; '35), Ch. Engr., Gillette Safety Razor Co., 27 W. 1st St., S. Boston; *for mail*, 59 Henry St., Atlantic.
HAWLEY, Thos. ('19), Life Member; Pres., Hawley Sch. of Engrg. 115 Huntington Ave., Boston; *for mail*, 137 Florence St., Melrose.
HAYES, Lawrence W. ('17; '35), V. P. & Treas., Hayes Pump & Mchy. Co., 125 Purchase St., Boston; *for mail*, 5 Penn Rd., Winchester.
HENNINGS, Wilbur C. (J'34), Inspr., Waltham Watch Co., Crescent St., Waltham; *for mail*, 100 Russett Rd., W. Roxbury, Boston.
HOBBS, Franklin W. ('11), Pres., Arlington Mills, 78 Chauncey St.
HOGAN, Patrick H. ('04; '14), 31 Ainsworth St., Roslindale.
HOLDEN, Carl M. ('24; '31; '35), M. E., Bailey Meter Co., 89 Broad St., Boston; *for mail*, 48 Otis St., E. Milton.
HONECKER, Norman C. (J'26), Branch Mgr., Charge Sales, Fedders Mfg. Co., Inc., 712 Beacon St., Boston; *for mail*, 92 Athelstane Rd., Newton Centre.
HOPKINS, Wm. E. ('32; '35; '35), Stone & Webster Engrg. Corp., 49 Federal St.; *for mail*, Y. M. C. A., 316 Huntington Ave.
HOSMER, Sidney ('02), V. P., Gen. Mgr., Edison Elec. Illum. Co. of Boston, 182 Tremont St.
HUCKLE, Myron S. ('30; '32), Pres., U. S. Diesel Corp., 89 Brighton Ave.
HUDSON, Ray M. ('30), Indus. Exec., New Eng. Council, 1032 Statler Bldg., Boston; *for mail*, 20 Appleby Rd., Wellesley.
HUNTER, C. J. (A'36), Dampney Co., Hyde Park.
IDELL, P. C. ('01; '09), Dist. Mgr., Babcock & Wilcox Co., 49 Federal St.
INGALLS, F. D. B. ('09), Htg. & Sales Engr., C. A. Dunham Co., 136 Federal St., Boston; *for mail*, 1 Hopkins St., Reading.
JEWETT, Francis B. ('25; '35), 1165 Hyde Park Ave., Hyde Park.
KAUFFMAN, Herbert P. ('23; '35), 97 Mt. Vernon St.
KELLEY, Edw. F. ('30), Engr., State Planning Bd., 175 Congress St., Boston; *for mail*, 30 Cleveland St., Arlington.
KELLOGG, Alfred S. ('08), Cons. Engr., 585 Boylston Rd.
KEYES, Frederic H. ('02), Bemis Industries, Inc., 40 Central St., Boston; *for mail*, 73 Elm Road, Newtonville.
KIHN, Wm. J. ('20; '35), Engr., C. L. Stevens Co., 1st Natl. Bank Bldg., Boston, Mass.; *for mail*, 14 Mading Terrace, Hillside, N. J.
KLEIN, August C. ('28), 49 Federal St.
KLOTZ, Harry J. ('13; '20; '35), Asst. Ch. Power Engr., Stone & Webster Engrg. Corp., 49 Federal St.
KRITZMAN, Saul A. (J'36), Turbine Dept., B. F. Sturtevant Co., Hyde Park.
LACROSSE, Emmart ('21), V. P. & Engrg. Mgr., Stone & Webster Engrg. Corp., 49 Federal St., Boston; *for mail*, 1840 Beacon St., Waban.
LANNON, Jas. J. ('19), Treas., Mgr., Grant Gear Wks., Inc., 154 W. 2nd St., S. Boston.
LATHAM, Allen, Jr. (J'31), M. E., Polaroid Corp., 168 Dartmouth St.
LAWTON, M. A. ('93), Treas., A. J. Morse & Son, Inc., 221 High St.
LINNELL, Clifton W. ('23; '35), Ch. M. E., Braman, Dow & Co., 239 Causeway St.
LYNCH, Timothy J. (A'24), Mgr., Allis-Chalmers Mfg. Co., 50 Congress St., Boston; *for mail*, 8 Ashmont St., Dorchester.
MABLEY, C. R., Jr. ('25; '32; '35), Asst. Sales Mgr., C. H. Sprague & Son Co., 100 Milk St.
MACDONALD, J. W. Franklin ('15), M. E., Parks-Cramer Co., 294 Washington St., Boston; *for mail*, 74 Hillside Ave., Newton.
MACNEISH, Archibald S. (J'29), Engr., Edw. C. Brown Co., 77 Summer St., Boston; *for mail*, 27 Lithgow St., Dorchester Center.
MAHAR, Jas. J. ('23), M. E., Sch. Comm., City of Boston, Rm. 21, 15 Beacon St., Boston; *for mail*, 68 L St., S. Boston.
MAIN, Chas. R. ('18), Treas., Chas. T. Main, Inc., 201 Devonshire St.
MAIN, Chas. T. ('85; F'36), Life Member; Manager, '14-'17; President, '18; *A.S.M.E. Medallist*, '35; Pres., Chas. T. Main, Inc., 201 Devonshire St.
MALLORY, Burton C. ('23; '34), Stone & Webster Engrg. Corp., 49 Federal St.
MARSH, Arthur B. ('20; '35), Mem. Firm, Wright, Brown, Quinby & May, 53 State St., Boston; *for mail*, 8 Sherman Rd., Melrose.
MAYER, Leo ('16; '35), Pres. Henry Cole Co., 54 Old Colony Ave., Boston; *for mail*, 8 Grant Ave., Newton Centre.
McELROY, John J. ('30), Supt., Maverick Mills, E. Boston.
McLAUTHLIN, Martin B. ('09), Treas., Geo. T. McLauthlin Co., 120 Fulton St., Boston; *for mail*, 65 Rockland Ave., Malden.
McLEAN, Wm. H. (J'32), Instr. Indus. Mgmt., Harvard Sch. of Business Admin., Soldiers Field.
McNELLIS, Jas. S. ('23; '24; '35), 141 Redlands Rd., W. Roxbury.
MILLER, J. F. G. ('10), V. P. Sales, B. F. Sturtevant Co., Hyde Park, Boston; *for mail*, 20 Chapel St., Brookline.
MINOT, Francis ('32), Partner, Owen & Minot, Treas., John G. Hall & Co., Inc., 84 State St.
MOKSU, Walter H. (J'33), Jenney Mfg. Co., 8 India St., Boston; *for mail*, State Sanitarium, Rutland.
MOORE, Frank H. ('26), 18 Cordis St., Charlestown.
MORELAND, Edw. L. ('21), Partner, Jackson & Moreland, Cons. Engrs., 31 St. James Ave.
MOWRY, Chas. Wm. ('26), Mgr., Inspc. Dept., Assoc. Factory Mutual Fire Ins. Cos., 184 High St.
MOYER, Jas. A. ('07), Dir. State Dept., Univ. Extension, State House.
MULLER, Robt. A. (J'24), Gen. Prod. Mgr., Atlas Plywood Corp., 934 Park Sq. Bldg., Boston; *for mail*, 29 Albion Rd., Wellesley Hills.
NAROMORE, Glenn C. (J'30), 471 Brookline Ave.
NELSON, Arthur L. ('28), Sr. Partner, Arthur L. Nelson, Engrs., 31 St. James Ave.
NOONAN, John D. ('35), Asst. Supt., Employers Liability Assurance Corp., Ltd., 110 Milk St., Boston; *for mail*, 290 Edge Hill Rd., E. Milton.
NORRIS, Edw. W. ('12; '21; '21), M. E. Div., Stone & Webster Engrg. Corp., 49 Federal St.
OAKES, Wm. H. ('16), Pres., Buerkel & Co., Inc., 22 Union Park St.
OLSON, Martin L. ('14; '19), Dir., Indus. Dept., Hyde Park High Sch., Central Ave., Hyde Park; *for mail*, 81 West St., Hyde Park.

ORROK, Geo. A., Jr. (J'31), Engr., Sta. Engrg. Dept., Edison Elec. Illum. Co. of Boston, 39 Boylston St., Boston; *for mail*, 5 Cleveland St., Cambridge.
OWEN, Ernest V. ('24), Chem. Engr., Charge Design, E. B. Badger & Sons Co., 75 Pitts St., Boston; *for mail*, 228 Norfolk Ave., Wollaston.
PATSCHEIDER, Walter A. ('26), Wks. Engr., Prod. & Maint., Walworth Co., 798—1st St., S. Boston.
PEASLEE, Dana N. ('31), M. E., Charge Estimates, E. B. Badger & Sons Co., 75 Pitts St.
PETERSON, J. D. (J'35), Engr. for Sales Organization, Ingersoll-Rand Co., 285 Columbus Ave.; *for mail*, 80 Marlborough St.
PETTIBONE, C. E. ('20), V. P., Mgr., Engrg. Dept., Am. Mutual Liability Ins. Co., 142 Berkeley St.
POOL, Clifford B. (J'23), Draftsman, Waltham Watch Co., Waltham; *for mail*, 77 Augustus Ave., Roslindale, Boston.
POWELL, E. B. ('04; '12), Cons. Engr., Stone & Webster Engr., Corp., 49 Federal St.
RADDEN, Chas. O. (J'36), 16 Oak Ave., W. Roxbury.
RALL, Chas. O. (J'30), Student, Harvard Graduate Sch. of Business Admin., Mellon Hall C-25, Soldiers Field, Boston, Mass.; *for mail*, 210 Amber St., Pittsburgh, Pa.
RATHZBURG, Paul D. (J'34), Pres., Nu-Way Welders, Inc., Boston; *for mail*, 85 Warick Rd., W. Newton.
REED, Alonzo B. ('21; '23), Cons. Engr., 89 Broad St.
REUTER, Peter T. ('21; '28; '35), Mgr., Boston Office, Bailey Meter Co., Rm. 523, 89 Broad St.
REYNOLDS, Frank W. ('12), 40 Central St.
RICH, Geo. R. ('35), Sr. Engr., Charge Flood Control Div., Eng. Office, U. S. War Dept., 13th Fl., Customhouse, Boston; *for mail*, 3 Francis Rd., Wellesley.
RICHARDS, Arklay S. ('36), Sales Engr., Brown Instrument Co., 285 Columbus Ave., Boston; *for mail*, 26 Parker St., Newton Centre.
RICHARDS, Homer F. ('31; '35), Powers Regulator Co., 125 St. Botolph St.
RICHARDSON, Edw. B. ('10), Owner, Richardson & Gay, Cons. Engrs., 12 Pearl St.
RICKARD, Henry C. (J'33), United Shoe Mchy. Co., 140 Federal St.
ROBERTSON, Baxter ('28), Engrg. Salesman, Aetna Engrg., Co., 108 Broad St., Boston; *for mail*, 25 Hawthorn Ave., Arlington.
ROSCHER, Alfred M. (J'33), Engr., Exper. Wk., Mass. Knitting Mills, Inc., 89 Bickford St., Boston; *for mail*, 37 Franklin St., Watertown.
ROWE, Hartley ('16), V. P. Charge Engrg., United Fruit Co., 1 Federal St.
RUSSELL, Walter B. ('06; '09), Dir., Franklin Union, 41 Berkeley St.; *for mail*, 58 Arborway, Jamaica Plain.
RYAN, Wm. F. ('17; '24), M. E., Design & Reports, Stone & Webster Engrg. Corp., 49 Federal St.
SCHEIBEL, Albert H. ('19; '35), Designing Engr., Stone & Webster Engrg. Corp., 49 Federal St., Boston; *for mail*, 406 Walnut St., Newtonville.
SCHMIDT, Hugh F. ('34), Sales Engr., John A. Roebling's Sons Co. of N. Y., 51 Sleeper St.
SCHMITZ, Edwin H. ('36), Fuel Engr., C. H. Sprague & Son, 10 Post Office Sq., Boston; *for mail*, 263 Payson Rd., Belmont.
SEWEL, Henry R. ('18; '35), Mgr., Air Conditioning Dept., B. F. Sturtevant Co., Damon St., Hyde Park.
SHEQUINE, Earl R. (J'23), Sales Engr., Whitty Mfg. Co., Inc., 216 High St., Boston, Mass.; *for mail*, 1481 Endicott Terrace, W. Englewood, N. J.
SIBLEY, Edw. W. ('18; '21), M. E., United Fruit Co., 1 Federal St., Boston; *for mail*, 18 Eliot Rd., Lexington.
SIMPSON, Fred'k C. ('19; '21), Treas., Geo. Allen & Son, Inc., 131 State St.
SMITH, Chetwood ('21), Mem. Firm, Smith & Dale, 457 Stuart St.
SMITH, Elmer ('13), Dist. Turbine Specialist, Gen. Elec. Co., 140 Federal St.; *for mail*, 70 Pinckney St.
SNOW, Benj. H. ('25), Sales Engr., Business & Indus. Air Conditioning, Gen. Heat & Appliance Co., 698 Beacon St., Boston; *for mail*, 339 Upham St., Melrose.
STARKWEATHER, Wm. G. ('97), Pres., Starkweather Engrg. Co., 79 Milk St.
STEARNS, Fred'k A. ('20; '24; '30), Asst. Prof. M. E., Sch. of Engrg., Northeast. Univ., 316 Huntington Ave., Boston; *for mail*, 66 Florence Ave., Melrose.
STEARNS, Karl T. ('17; '35), Engr., Steam Div., New Eng. Power Engrg. & Serv. Corp., 89 Broad St., Boston; *for mail*, 73 Hawthorne Ave., Auburndale.
STEINBACH, Edw. S. ('21; '22), Stone & Webster Engrg. Corp., 49 Federal St.
STETSON, Geo. W. (A'18), Propr., Stets Co., 141 Milk St.
STEWART, Clarence R. ('25), Engr., M. E. Div., Stone & Webster Engrg. Corp., 49 Federal St., Boston; *for mail*, 92 School St., Arlington.
STEWART, Warren D. ('36), Engr., Stone & Webster Engrg. Co., 49 Federal St., Boston; *for mail*, 37 Thornton St., Wollaston.
STODDARD, Clifford J. ('15), Supt., Engrg. Dept., Employers Liability Assurance Corp., Ltd., 33 Broad St.
STORROW, Jas. J., Jr. ('21; '25; '35), 80 Federal St., Boston; *for mail*, 40 Pine Rd., Chestnut Hill.
STRUCK, H. W. ('18; '24), 91 Bay State Rd.
SULLIVAN, Edw. L. ('20; '35), Combustion Engr., Jackson & Moreland, 31 St. James Ave., Boston; *for mail*, 564—5th St., S. Boston.
SUTTON, Harry M. ('19; '22), Sr. Partner, H. M. Sutton Engrs., 201 Devonshire St.
TABER, Geo. A. ('22), Cons. Engr., 73 Cornhill.
TAYLOR, Geo. C. ('28), M. E., Sales, Westinghouse Elec. & Mfg. Co., 10 High St.
TENNEY, Albert B. ('96; '04), Pub. Utility Executive, Chas. H. Tenney & Co., 200 Devonshire St.
THANISCH, Rudolph J. ('14), Asst. Engr., City of Boston, 602 City Hall Annex.
THOMPSON, Albert W. ('00; '07), Engr., Mgr., Parks-Cramer Co., 1102 Old South Bldg.
THOMPSON, Ralph E. ('14; '35), Pres., Wm. L. Gilbert Clock Corp., 50 Congress St.
THOMPSON, Sanford E. ('09), Pres., Thompson & Lichtner Co., Inc., 620 Newbury St.
UHL, Wm. F. ('12), Hyd. Engr., Chas. T. Main Inc., 201 Devonshire St.
VAUGHAN, John F. ('17), Vaughan Engrs., 3 Joy St.
WEBER, Rudolf L. ('20), Stone & Webster Engrg. Corp., 49 Federal St., Boston; *for mail*, 34 Ingraham Rd., Wellesley.
WELCH, Chester W. ('34), M. E., Indus. Div., Stone & Webster Engr. Corp., 49 Federal St., Boston; *for mail*, 2 Severance Terrace, Lynn.
WELD, Alfred O. ('13), Propr., Geo. A. Weld & Co., 120 Milk St., Boston; *for mail*, 48 Winthrop St., Winchester.
WHIPPLE, Geo. F. (A'17), Educational Dir., Whipple Tech. Libraries, 50 Beacon St.
WHITE, Alden D. (J'34), M. E., Stone & Webster Engrg. Corp., 49 Federal St.; *for mail*, 216 Commonwealth Ave.
WHITE, Harold Eaton ('25; '35), Engr., Mech. Div., Stone & Webster, Inc., 49 Federal St., Boston; *for mail*, 150 High St., Reading.
WIGHTMAN, F. A. ('24), Loco. Inspr., Dept. Pub. Utilities, 100 Nashua St., Boston; *for mail*, 14 Calvin Rd., Newtonville.
WILBER, Dana W. ('31), Engr., Steam Div., Sta. Engrg. Dept., Edison Elec. Illum. Co. of Boston, 39 Boylston St.
WILLIAMS, Albert Blake ('19), Asst. Engr. Mgr., Stone & Webster Engrg. Corp., 49 Federal St.
WILLIAMS, Ralph L. (J'24), Rep., Hagan Corp. & Hall Labs., Inc., 49 Federal St.
WORCESTER, Henry E. (A'03), V. P., United Fruit Co., also V. P., Revere Sugar Refinery, 1 Federal St., Boston; *for mail*, 111 Church St., Winchester.
WRIGHT, Robt. W. (J'32), Gen. Mgr., Wright Diesel Eng. Co., 800 Statler Office Bldg., Park Sq.
YOUNG, C. Jas. ('22), Ch. Engr., Charge Design, Constr. & Opera., Quincy Market Cold Storage & Warehouse Co., 8 "T" Wharf; *for mail*, 36 Ashfield St.
ZELLER, Jos. W. ('28), Head M. E. Dept., Northeast. Univ., 316 Huntington Ave.

BRIDGEWATER, Boston Section

McLEAN, Robt. W. ('07; '13), Mgr. M. E., Carver Cotton Gin Co., Whitman St., E. Bridgewater; *for mail*, 91 Bedford St., Bridgewater.

BROCKTON, Boston Section

HAMILTON, Kenneth D. ('16; '25), Indus. Engr., Sales, Norfolk Paint & Varnish Co., Newport Ave., Quincy; *for mail*, 48 Tilton Ave., Brockton.
MONTGOMERY, Wm. J. ('17; '35), Head Mch. Dept., Brockton High Sch.; *for mail*, 14 N. Ash St.
WASHBURN, Wm. S. ('91), Owner, Wm. S. Washburn, Plant Stands, 365 Moraine St.

BROOKLINE, Boston Section

BALTHASAR, Frank L. ('25; '27; '35), Res., Engr. Inspr., Pub. Wks. Admin., Washington, D. C., *for mail*, 2 Sutherland Rd., Brookline, Mass.
BRIGHAM, Edmond F. ('13), Retired; 142 Clinton Rd.
BUSHNELL, Fred. N. ('91), Manager, '17-'20; Vice-Chmn., Bd. Dir., Stone & Webster Engrg. Corp., 49 Federal St., Boston; *for mail*, 1080 Beacon St., Brookline.
CHARD, Thos. Brooks (J'33), Pres., Treas., Auburn Motors, Inc., 790 Commonwealth Ave., Boston; *home address*, 45 Pine Rd., Brookline.
KENNEDY, Grafton S. (J'17), Major, U. S. A., 79 Holland Rd.
PRICE, Samson L. (J'35), 165 Winthrop Rd.,

CAMBRIDGE, Boston Section

ABOOZBEEB, Azeez E. (J'33), Prod. Mgr., Perin Walsh Co., 5th & Bent Sts., Cambridge; *for mail*, 34 Hudson St., Boston.
BARTLETT, Henry ('97), 985 Memorial Dr.
BELLAMY, Leon ('14), Pres., Bellamy, Robie & Sargent, Inc., 45 Main St.
BENSON, John Goffe (J'36), Asst. Instr. M. E., Mass. Inst. of Tech., 69 Massachusetts Ave.
BERRY, C. Harold ('19; '21), Prof. M. E., Graduate Sch. of Engrg., Harvard Univ., Pierce Hall.
BLAKEMAN, Winfield W. ('13), Supt., Blanchard Mch. Co., 64 State St., Cambridge; *for mail*, 30 Hammond Rd., Belmont, 78.
BROWN, Robt. F. (J'34), 215 Norfolk St.
BUCKINGHAM, Earle ('13; '35), Prof. M. E., Mass. Inst. of Tech.
BUSH, V. ('32), V. P., Dean of Engrg., Mass. Inst. of Tech., Cambridge; *for mail*, 404 Common St., Belmont.
CHARNLEY, Thos. L. (J'36), Lever Bros. Co., 164 Broadway; *for mail*, 50 Broadway.
COMPTON, Karl T. ('33), Pres., Mass. Inst. of Tech.
CROGHAN, John T. ('09; '14), M. E., Charge Devel., Power, Maint., Boston Woven Hose & Rubber Co., 29 Hampshire St., Cambridge; *for mail*, 574 Chestnut St., Waban.
CUTLER, Wallace M. ('27), Owner, Wallace M. Cutler Associates, 195 Broadway.
DRAPER, Chas. S. ('34; '35), Asst. Prof. Aero. Engrg., Mass. Inst. of Tech., 69 Massachusetts Ave.
DURANT, Aldrich ('06; '13), Business Mgr., Harvard Univ., Lehman Hall.
EAMES, Jesse J. ('18), Assoc. Prof. Exper. Engrg., Mass. Inst. of Tech.
EMMONS, Howard W. (J'35), Post-Graduate Student, Harvard Univ., 42 Prentiss St.
FEYLING, Per L. F. ('35), Wks. Mgr., Whitehead Metal Products Co. of N. Y., Inc., 235 Bridge St., Cambridge; *for mail*, 140 Gilbert Rd., Belmont.
FLINT, Thos. (J'31), Asst. in M. E., Harvard Univ., Cambridge; *for mail*, Willard Rd., Concord.
FOGLER, Ben B. ('12; '18; '22), M. E., Charge Engrg., Arthur D. Little, Inc., 30 Charles River Rd.
FRY, Carl V. ('29; '35), Gen. Mgr., Cambridge Steam Corp., 46 Blackstone St.
FULLER, Chas. Edw. ('12), Prof. Theoretical & Applied Mechanics, Mass. Inst. of Tech.
HALL, H. Elmer ('28; '34; '35), Instr. M. E., Mass. Inst. of Tech., 1-304 Dept. of M. E.
HARPER, Kennard Watson (J'31), Engr., Mico Instrument Co., 10 Arrow St., Cambridge; *for mail*, 9 Cushing St., Wollaston.
HERMAN, E. Olney ('22; '35), Field Engr., Tech. Control & Mgmt., Arthur D. Little, Inc., 30 Charles River Rd., Cambridge, Mass.; *for mail*, Tiffany Enameled Brick Co., P. O. Box 32, Momence, Ill.
HERRICK, Daniel A. ('15; '19; '24), Gen. Mgr., Julian d'Este Co., 6 Spice St., Charlestown, Boston; *for mail*, 27 Agassiz St., Cambridge.
HERSEE, Fred'k C. (A'19), Gen. Mgr., Cambridge Screw Co., 63 Potter St.
HOAGLAND, John E. ('30; '35), Foreman, Gillette Safety Razor Co., Boston; *for mail*, 292 Harvard St., Cambridge.
HOLT, Jas. ('33), Asst. Prof. M. E., Mass. Inst. of Tech.
HOTTEL, H. C. ('35), Assoc. Prof. Fuel Engrg., Mass. Inst. of Tech.
HUNSAKER, Comdr. J. C. ('33), Head, Dept. M. E., Mass. Inst. of Tech.
JACKSON, Dugald C. ('90), Prof. Emeritus, Mass. Inst. of Tech.; *for mail*, 5 Mercer Circle.
JOHNSTON, Wm. A. ('11), Prof. of Theoretical & Applied Mechs., Mass. Inst. of Tech., Cambridge; *for mail*, 35 Hillside Terrace, Belmont.
JUNKER, Alex J. (J'32), Student, Mass. Inst. of Tech. Students Dormitory, Nichols 303.
KEENAN, Jos. H. ('26; '30; '34), Assoc. Prof. M. E., Mass. Inst. of Tech., Cambridge; *for mail*, 52 Oakland St., Medford
KING, Henry F. ('33; '35), Instr., Mass. Inst. of Tech., 69 Massachusetts Ave.
KNIGHT, Sidney ('31; '35), 343 Mellon Hall, Harvard Univ.
KOHLER, John Henry ('31), Engr., Charge of Mch. Design, United Carr Fastener Co., 31 Ames St.
LESSELLS, John M. ('23), Assoc. Prof., Dept. M. E., Mass. Inst. of Tech.
LEWIS, Frank M. ('28), Prof. Mar. Engrg., Mass. Inst. of Tech., Cambridge; *for mail*, Derby Lane, Weston.
LUNN, John A. ('17; '25; '29), Exec. Asst. to Pres., Dewey & Almy Chem. Co., 62 Whittemore Ave.; *for mail*, 37 Larch Rd.
MACGREGOR, Chas. W. (J'31), Instr. Mech. Engrg., Mass. Inst. of Tech.; *for mail*, Apt. 45, 19 Garden St.
MAGRATH, Howard A. (J'33), Mass. Inst. of Tech., Box 123, Dormitories.
MARKS, Lionel S. ('97; '04), Prof. M. E., 215 Pierce Hall, Harvard Univ.

MICHEL, Leopold R. (J'36), Asst. in M. E. Dept., Mass. Inst. of Tech.
MILLS, Blake (J'35), Asst. in M. E. Dept., Mass. Inst. of Tech.; *for mail,* Graduate House, M. I. T.
MULLIGAN, Jas. E. (J'29), Instr. E. E., Mass. Inst. of Tech.
MURRAY, W. M. (J'35), Instr., M. E. Dept., Mass. Inst. of Tech.
NASH, Russell K. ('29), Exper. Engr., Boston Blacking Co., Cambridge; *for mail,* 576 Washington St., Brookline.
NORTON, A. E. ('11), Prof. Applied Mechanics, Harvard Univ., 307 Pierce Hall.
NORTON, Charles L. ('10), Dir., Div. Indus. Cooperation, Mass. Inst. of Tech.
PARK, Chas. F. ('15), Prof. M. E., Dir. Mech. Labs., Mass. Inst. of Tech.
PAULSEN, John ('32; '35), Private Asst. to Prof. G. B. Haven, of Mass. Inst. of Tech., Rm. 3-465, Cambridge; *for mail,* 146 Walnut St., Dorchester.
RAYMOND, Fairfield E. ('21; '26; '35), Assoc. Prof. Indus. Research, Mass. Inst. of Tech.; *for mail,* 28 Meadow Way.
RIGHTMIRE, Brandon G. (J'35), Asst. in M. E. Instr. in Fluid Mechanics, Mass. Inst. of Tech.
RILEY, Jos. C. ('09), Prof. Heat Engrg., Mass. Inst. of Tech.
RITCHINGS, Robt. H. (J'35), Graduate Student, Mass. Inst. of Tech.
RYDER, Myron W. ('29; '35; '35), Engr., House Htg., Cambridge Gas Light Co., 354—3rd St., Cambridge; *for mail,* 135 School St., Belmont, Mass.
SASS, Clifton H. ('25), Mech. Supt., Simplex Wire & Cable Co., 66 Sidney St.
SAURWEIN, G. K. ('15; '19), Supt. Engrg. Dept., Harvard Univ., Lehman Hall.
SCHELL, Erwin H. ('13; '21; '35), Charge, Dept. of Business & Engrg. Admin., Mass. Inst. of Tech.
SOROKA, Walter W. (J'31), Instr. M. E., Mass. Inst. of Tech.
STAUFFER, Ralph D. ('22; '30), Ch. Engr., Charge Design & Constr., New Eng. Gas & Elec. Assn., 719 Massachusetts Ave.
SVENSON, Carl L. (J'20), Asst. Prof. M. E., Mass. Inst. of Tech., Memorial Dr.
TAFT, Theo. H. ('03; '10), Assoc. Prof., Heat Engrg., Mass. Inst. of Tech., 69 Massachusetts Ave.
THOMSON, Geo. H. ('21; '35), New Eng. Rep., Swartwout Co., 143 Broadway.
UDDENBERG, Robt. C. (J'36), Graduate Student, Graduate House, Mass. Inst. of Tech.
VEINOTE, Thos. H. ('21; '35), Supt. Power, Blake & Knowles Wks., Worthington Pump & Mchy. Corp., Cambridge; *for mail,* 147 Cypress St., Newton Centre.
VOLL, Walter C. ('22; '27; '35), Harvard Graduate Sch. of Education; *for mail,* Harvard Apts., 74 Kirkland St.
VOSE, Robt. W. (J'32), Instr., Matls. Testing, Mass. Inst. of Tech.
WARREN, Ralph L. ('17), V. P., Treas., Warren Bros. Co., 38 Memorial Dr., Cambridge; *for mail,* P. O. Box 1869, Boston.
WIGGIN, Herbert A. (J'28), Asst. Engr., R. H. Baker Co., Inc., Cambridge; *for mail,* 34 Thomas Rd., Wellesley.
WRIGHT, Donald M. ('28; '36), Engr., Charge Store Design, Constr. & Maint., Great A. & P. Tea Co., P. O. Box 1953, Boston; *for mail,* 14 Avon Pl., Cambridge.

CANTON, Boston Section

FLETCHER, Albion R. (J'35), 371 Washington St.

CENTERVILLE, Boston Section

SNYDER, Geo. T. ('12), Retired; P. O. Box 278, Centerville, Cape Cod.

CHELSEA, Boston Section

DOROFF, Stanley W. (J'36), Instr. Eng. Design, Mass. Diesel Inst., 88 St. Stephen St., Boston; *for mail,* 9 Crescent Ave., Chelsea.

CHICOPEE, Western Massachusetts Section

TILSON, Howard ('15; '23; '31), Mgr., Bat & Tennis Dept., A. G. Spalding & Bros.

CHICOPEE FALLS, Western Massachusetts Section

BARKS, Geo. T. (J'33), Engr. Asst., Charge Tire Constr., Fisk Rubber Corp., Grove St., Chicopee Falls; *for mail,* 53 Ridgewood Terrace, Northampton.
DEXTER, Albert J. ('20), Draftsman, Fisk Rubber Corp., Chicopee Falls; *for mail,* 21 Montclair St., Springfield.
LITTLEFIELD, Lloyd M. (J'27), Research Asst., Fisk Rubber Corp., Chicopee Falls; *for mail,* 187 Florida St., Springfield.
MAYNARD, Chas. E. ('31), Factory Mgr., Fisk Rubber Corp.

CLINTON, Worcester Section

ALBERGA, Glenn H. (J'34), Engr. & Gen. Admin., Blackstone Plush Mills, Inc., School St.
CONNERY, Wm. H., Jr. (J'36), 101 Walnut St.
OFFICER, Wesley J. ('28), Factory Mgr., Blake Mfg. Co., Green St.

COCHITUATE, Boston Section

BENEDICT, Walter L. (J'35), 25 W. Plain St.

COHASSET, Boston Section

BATES, Nathan W. (J'35), R. F. D.
WILSON, Chas. (J'35), S. Main St.

DANVERS, Boston Section

COOK, Edw. L. (J'34), Asst. Office Mgr., Baker Ice Mch. Co., Inc., 102—5th Ave., New York, N. Y.; *home address,* 68 Holten St., Danvers, Mass.
FRASER, Thos. T. ('27), 83 Conant St.

DEDHAM, Boston Section

MACMILLAN, Donald S. (J'34), 193 Court St.

DORCHESTER, Boston Section

ANDREWS, B. R. ('17; '35), Treas., Andrews & Goodrich, Inc., 336 Adams St.
BAUR, Wm. E. (J'33), Mch. Tool Engr., River Wks., Gen. Elec. Co., W. Lynn; *for mail,* 10 Corwin St., Dorchester.
CARROLL, Jos. F. (J'32), 84 Sumner St.
GORDON, Robt. J. ('18; '26), Plant Engr., Walter Baker & Co., Dorchester.
KLEIN, Julian J. (J'33), Spec. Apprentice, New Haven R. R., New Haven, Conn.; *for mail,* 44 Charlotte St., Dorchester, Mass.
O'REGAN, Wm. F. ('22; '35), Ch. Engr., Charge Power, Boston Insulated Wire & Cable Co., 65 Bay St.; *for mail,* 23 Crockett Ave.
ROLLAND, Geo. A. ('21; '35), Independent Engr., 163 Milton St.
SWANSON, Carl R. (J'35), Asst. Maint. Engr., Tyer Rubber Co., Railroad St., Andover; *for mail,* 5 Althea St., Dorchester.
SZYDLOWSKI, Edw. J. (J'35), Machinist, Condit Elec. Mfg. Co., 1344 Hyde Park Ave., Hyde Park, Boston; *for mail,* 215 Hancock St., Dorchester.

DUDLEY, Worcester Section

WILLIAMS, Herman B. (J'32), Employment & Personnel Dir., Grosvenor-Dale Co., N. Grosvenor Dale, Conn.; *for mail,* Dudley, Mass.

EAST BRIDGEWATER, Boston Section

CHANDLER, Clarence A. ('00), Gen. Mgr., Chandler Constr. Co., 37 N. Central St.; *for mail,* 344 Central St.

EAST HARWICH, Boston Section

VINCENT, Harry S. ('21), Cons. Engr.

EAST LYNN, Boston Section

LAUCKNER, Chas. G., 3d (J'36), 37 Porter St.
SHAW, Darrell E. ('27; '35), 36 Fair Oakes Ave.
SOUTHWICK, Bertram H. ('24; '25; '35), M. E., Plant Engrg. Dept., River Wks., Gen. Elec. Co., 920 Western Ave., W. Lynn; *for mail,* 37 Elvir St., E. Lynn.

EASTON, Boston Section

McNAMARA, Roger A. (J'31), Bay St.

EAST WALPOLE, Boston Section

CONRAD, Chas. W. ('21), V. P., Dir. Mfg., Bird & Son, Inc.
GUTTORMSEN, Paul A ('25), Ch. Engr., Charge Power & Steam, Bird & Son, Inc.; *for mail,* 13 Park Lane.
McSWAIN, Wm. D. (J'32), Box 30.
SHEEHAN, Jos. A. ('22; '28; '35), Plant Engr., Bird & Son, Inc.
WYMAN, G. Russell, Jr. (J'30), Asst. Mech. Supt., Hollingsworth & Vose Co.

EAST WEYMOUTH, Boston Section

DAVIS, Noble L. (J'34), 190 Lake Shore Dr.
RAUCH, Lawrence, K. (J'32), 81 Church St.

ERVING, Western Massachusetts Section

JOHNSON, Chas. A. (J'33), P. O. Box 2.

EVERETT, Boston Section

CIOFFI, Mario V. (J'36), 18 Langdon St.
LIND, Francis T. (J'34), Designer & Metallurgist, H. K. Porter, Inc., 6 Ashland St.; *for mail,* 127 Central Ave.
ROETZER, Alfred Arnold (J'36), Graduate Student, M. E. Dept., Mass. Inst. of Tech., Cambridge; *for mail,* 79 Garland St., Everett.
SMITH, Henry R. ('30), Mar. Supt., Colonial Beacon Oil Co., Inc., Everett; *for mail,* 9 Staples St., Melrose.
STONE, Philip I. (J'35), 27 Sammet St.
THOMPSON, Albert L. ('31), Sales Promotion, Lub. Engr., Colonial Beacon Oil Co., Inc., 36 Beacham St., Everett; *for mail,* 106 Oakdale Ave., Dedham.

FALL RIVER, Providence Section

DALEDA, Joseph (J'34), 4 Lenox St.
HETTRICK, Geo. D. ('28), Gen. Supt., Charge Opera., Montauk Elec. Co., Box 389.
MOONEY, David A. (J'34), 109 Irving St.
PARKS, Geo. U. ('30), Asst. Gen. Mgr., Montauk Elec. Co.; *for mail,* P. O. Box 389.
POLLOCK, Hyman Louis (J'30), Salesman, Am. Store Fixture Co., 883 Pleasant St., Fall River; *for mail,* Ocean Grove.
STEWART, Albert A. (J'32), 28 Hanover St.

FITCHBURG, Worcester Section

BAILEY, F. E. ('31; '35), Plant Engr., Crocker-Burbank & Co. Assn.
GROSS, Edgar Wm. (J'31), 196 Leighton St.
JONES, Fiske R. ('27), Supt., Simonds Saw & Steel Co., 55 North St.
KIMBALL, Irving D. (A'23), Indus. Exec., Parks-Cramer Co.; *for mail,* P. O. Box 444.
SHELDON, Thos. C. ('84), Treas., Fitchburg Duck Mills, Duck Mill Rd.; *for mail,* 8 School St.
WILCOX, Walter M. (J'36), Asst. Foreman, Hacksaw Dept., Simonds Saw & Steel Co., Falulah Rd.; *for mail,* 9 Park St.

FLORENCE, Western Massachusetts Section

SWIFT, Gordon S. (J'35), Asst. Pur. Agt., Prophylactic Brush Co., Pine St.

FORT DEVENS, Worcester Section

PURSELL, Wm. (J'31), 1st Lieut., Engr. Res., Charge Commissary Supplies, Fort Devens.

FOXBORO, Boston Section

BRAGG, David Kendall (J'32), Jr. Engr., Research Dept., Foxboro Co., Neponset Ave.; *for mail,* 28 School St.
BRISTOL, Bennet B. ('18), Treas., Foxboro Co.; *for mail,* 7 Howard Ave.
CROCKER, Percival B. ('21; '27; '35), Pres. & Asst. Mgr., Sentry Co., Main St.

FRAMINGHAM, Boston Section

ANGIER, Edw. H. (A'17), Pres., Treas., Angier Corp.
BROWN, Harry Wolston ('30; '35), Sales Engr., Research & Devel., Angier Corp., Fountain St.
CHIPMAN, Fred W. ('19), Treas., Gen. Mgr., Internatl. Engrg. Wks., Inc., Box 71.
GREENHALGH, John ('21; '35), M. E., Dennison Mfg. Co.; *for mail,* 19 Robertson Rd.
LEWIS, Percy J. (J'26), Sales Engr., Barber Colman Co. of Mass., Eames St.
SCOTT, Henry F. ('07), 213 Union Ave.

GEORGETOWN, Boston Section

KILBOURNE, Hubert G. ('25), Cons. Engr.

GLOUCESTER, Boston Section

BIRDSEYE, Clarence (A'30), Pres., Birdseye Elec. Co., 51 Commercial St.
TRENOR, Albert D. ('14; '35), V. P., Charge Patents, Hammond Research Corp., Hesperus Ave.; *for mail,* Crows Nest.

GREENFIELD, Western Massachusetts Section

BRYANT, Elmer J. ('21; '28), Mgr., Gage & Reamer Depts., Greenfield Tap & Die Corp., Sanderson St.
KRYSIN, Jos. A. (J'36), 106 Chapman St.
McWILLIAMS, Richard L. (J'29), Boston & Maine R. R.
SMITH, Herbert J. ('13; '26), Supt., Threadwell Tool Co.; *for mail,* 31 West St.

HAVERHILL, Boston Section

AGRONIN, Tany (J'31), Designing Draftsman, Lawrence Mch. & Pump Co., 371 Market St., Lawrence; *for mail,* 37 Highland Ave., Haverhill.
RYAN, Jas. E. ('22; '35), Asst. Ch. Engr., Haverhill Elec. Co., 161 Water St., Haverhill; *for mail,* 145 State St., Newburyport.
WARNER, John E. A. ('20; '35), Ch. Engr., Haverhill Boxboards, Inc.

HOLYOKE, Western Massachusetts Section

BAKER, Dickerson G. ('05), Ch. Engr., Mchy. Devel. Dept., Am. Thread Co.; *for mail,* 1 Yale St.

BIDWELL, Paul W. ('16; '23), Gen. Supt., White & Wyckoff Mfg. Co.; *for mail*, 16 Lexington Ave.
BOSWORTH, Ralph L. ('18; '35), Plant Engr., Design, Maint. & Opera., Chem. Paper Mfg. Co., Foot of Jackson St.; *for mail*, 26 Amherst St.
BURKHARDT, Everett R. ('23; '30; '32), M. E., Holyoke Water Power Co., 1 Canal St., Holyoke; *for mail*, 925 Worthington St., Springfield.
MARRAN, Vincent P. ('19; '22), Gen. Mgr., Walsh's Holyoke Steam Boiler Wks., 110 Appleton St.; *for mail*, 1801 Northampton St.
METCALF, Frank H. ('10), Pres. & Treas., Farr Alpaca Co., 60 Jackson St.
NEWCOMB, Robt. E. ('07; '16; '18), Pres., Treas & Engr., Puritan Gasoline Co., 1600 Northampton St.; *for mail*, 274 Pleasant St.
SKINNER, Joseph A. (A'16), Treas., Wm. Skinner & Sons.
SMETHURST, Jarvis R. ('19; '35), Ch. Engr., Farr Alpaca Co., Holyoke; *for mail*, 16 Walton St., Chicopee.
STANDISH, Edw. K. ('21), M. E., Devel. New Mchy., Merrick Mills, Am. Thread Co.
TOWNE, Jos. M. ('18), V. P., Natl. Blank Book Co.
WILLIAMSON, Daniel W. ('19), Mech. Supt., Farr Alpaca Co.

HOPEDALE, Worcester Section

BROWN, Carl D. ('21; '24), Ch. Draftsman, Draper Corp.; *for mail*, 101 Dutcher St.

HUBBARDSTON, Worcester Section

MERRIAM, Henry P. ('87; '96), Retired.

HUDSON, Boston Section

CLARKE, Chas. A. ('23), Pres., Universal Boring Mch. Co., 312 Main St.

INDIAN ORCHARD, Western Massachusetts Section

BENSON, Arthur E. ('26; '34; '35), Engr., Charge Tire Constr., Fisk Rubber Corp., Chicopee Falls; *home address*, 204 Oak St., Indian Orchard.
JOHNSON, Harold K. ('27; '35), Draftsman, Chapman Valve Mfg. Co., Indian Orchard; *for mail*, 33 Wellesley St., Springfield.
KLIGMAN, A. R. ('26; '32), Engr., Charge Design, Chapman Valve Mfg. Co.; *for mail*, 110 Hampden St.

LAWRENCE, Boston Section

FOSTER, S. L., Jr. (J'35), Welding Engr., J. W. Bolton & Sons, Inc., 9 Osgood St.; *for mail*, Y. M. C. A.
GRUBER, G. John ('24), M. E., Charge Design, Lawrence Mch. & Pump Corp., 371 Market St., Lawrence; *for mail*, 19 Quincy St., Methuen.
HAMBLET, George W. ('21), Propr., Hamblet Mch. Co.; *for mail*, 506 Lowell St.
LEARNARD, Harry D. ('21), Exec. Engr., Charge All Engrg., Pacific Mills.
PRAETZ, Edw. F. (J'21), Instr., Mech. Drawing, Lawrence High Sch.; *for mail*, 31 Avon St.
RALTON, Francis A. ('22; '23), Engr., Charge Power Plant Design, Am. Woolen Co., Shawsheen Village; *for mail*, 50 Oakwood Ave., Lawrence.
REED, Thos. E. ('29), Plant Engr., Everett Mills, Lawrence Factories, Inc., Lawrence; *for mail*, P. O. Box 222, Ballardvale.
SALIBA, Edw. M. (J'32), Engr., Specialty Engrg. Co., Inc., 594 Essex St.; *for mail*, 278 Broadway.
SCHWARZ, Franz H. ('88; '18), Retired; 165 Ferry St.

LEE, Western Massachusetts Section

PACKARD, Roland A. ('18), Ch. Engr., Smith Paper, Inc.; *for mail*, Whiteholme Rd.

LENOX, Western Massachusetts Section

PENVENNE, Jean (J'34), Hubbard St.

LEOMINSTER, Worcester Section

BELL, Albert O. (J'36), 47 Hale St.
HARRINGTON, Archie E. ('31; '35), Engr., Charge Power, E. I. du Pont de Nemours & Co., Lancaster St.; *for mail*, Grove Terrace.
PERSON, Earl R. ('28), Mech. Exper. Engr., Du Pont-Viscoloid Co., 511 Lancaster St.; *for mail*, 16 Devon Rd.
STADTHERR, Nicholas G. (J'35), Indus. Engr., Plastics Dept., E. I. du Pont de Nemours & Co.

LONGMEADOW, Western Massachusetts Section

STONE, E. Wadsworth ('15; '18; '27), Research & Cons. Engr., Bigelow Sanford Carpet Co., Inc., Thompsonville, Conn.; *for mail*, 216 Ellington Rd., Longmeadow, Mass.

LOWELL, Boston Section

BALL, Herbert J. ('27), Prof., Head Textile Engrg., Lowell Textile Inst.
BUTTERFIELD, Maurice A. ('27), Sub-Master, Lowell Vocational Sch.; *for mail*, 12 June St.
CUNNINGHAM, Francis ('30), Treas., John A. Stevens, Inc., 16 Shattuck St.
FLATHER, Fred'k A. ('92), Treas., Boott Mills, 79 Milk St., Boston; *for mail*, 68 Mansur St., Lowell.
HINCKLEY, Wm. C., Jr. (J'33), Draftsman, Frosted Wool Process Co., Lowell Textile Inst.; *for mail*, 698 Westford St.
LORD, HARRY C. ('30), Pres., John A. Stevens, Inc., 16 Shattuck St.

LUDLOW, Western Massachusetts Section

THOMPSON, J. Geo. H. (J'34), M. E., Design Wk., Ludlow Mfg. & Sales Co.; *for mail*, 26 Prospect St.

LYNN, Boston Section

BUFFINTON, Alfred L. (J'36), 23 Nichols St.
CUTTER, Geo. A. ('96; '04), 161 Pleasant St.
DANA, Benton P. (J'36), Draftsman, Gen. Elec. Co., Western Ave., W. Lynn; *for mail*, 17 Sagamore St., Lynn.
EDDY, Jas. H. (J'31), 24 Baker St.
HAMILTON, Arthur S., Jr. (J'35), M. E. Motor Dept., River Wks., Gen. Elec. Co., Western Ave., W. Lynn; *for mail*, 15 Franklin St., Lynn.
HASTINGS, Chas. F. ('21), Retired; 92 Lakeview Ave.
NESSON, Israel (J'32), Mch. Designer, United Shoe Mch. Corp., Beverly; *for mail*, 30 Surfside Rd., Lynn.
PHILLIPS, Wm. Henry John (J'28), Asst. to Supt., Meter Dept., Gen. Elec. Co., Federal St., W. Lynn; *for mail*, Thomson Club, 24 Baker St., Lynn.
STANYAN, S. W. ('22; '35), Factory Mgr., Hoague-Sprague Plant of United Shoe Mchy. Corp., 130 Eastern Ave., Lynn; *for mail*, 4 Mystic Bank, Arlington.
WHITE, Herbert J. ('09), 7 Lovett Pl.

LYNNFIELD CENTER, Boston Section

ALLEN, Chauncey D. ('31), Serv. & Sales Engr., J. S. Coffin, Jr. Co., Englewood, N. J.; *for mail*, Summer St., Lynnfield Center, Mass.
CATTERMOLE, Lester G. ('17; '19; '30), Mgr., L. G. Cattermole & Associates, Box 14.

MALDEN, Boston Section

DILLON, Frank H. (J'24), Cons. Engr., 28 Gale St.
KEVORKIAN, Geo. Robt. (J'35), 72 Clark St.
NUTE, Edwin L. ('11; '26), Mech. Supt., Converse Rubber Shoe Co., Malden; *for mail*, 12 Wave Ave., Wakefield.
PAUL, Chas. Van S. (A'26), Pres., Treas., Malden Bronze Founders, Inc., 81 Broadway, Malden; *for mail*, 722 Commonwealth Ave., Boston.
ROBINSON, Edw. P. ('91), Retired; 117 Maple St.

MATTAPOISETT, Boston Section

HILLER, Jos. L. (A'07), Cons. & Contrg. Engr., Prospect Rd.

MAYNARD, Boston Section

HARTIN, Frank Robt. (J'35), 141 Summer St.
HEFFERNAN, Wm. H. ('29), Gen. Supt., Am. Powder Div., Am. Cyanamid & Chem. Corp., Maynard; *for mail*, 276 Florence Rd., Waltham.

MEDFORD, Boston Section

CHACE, Warren F. (J'36), 337 Lawrence Rd.
COUPAL, E. Arthur ('27; '35), Designing Engr., 126 Lincoln Rd.

MELROSE, Boston Section

HIGGINS, Geo. Frederick ('86; '06), Universal Pressed Steel Co.; *for mail*, 41 Mt. Vernon St.
KEDY, Stiles F. ('16), Cons. Engr., 1200 Franklin St., Melrose Highlands.
MASON, Stanley C. (J'34), Underwriting Dept., Am. Mutual Liability Ins. Co., Boston; *for mail*, 111—1st St., Melrose.
PRESBY, Leroy Q. ('20), Supt., Am. Stay Co., 299 Marginal St., E. Boston; *for mail*, 50 Trenton St., Melrose.

MIDDLEBORO, Boston Section

STAFFORD, Philip W. (J'34), R. D. 1, Box 138.

MILFORD, Worcester Section

ROBINSON, Emerson Jos. (J'35), Designing & Drafting, New Eng. Butt Co., 304 Pearl St., Providence, R. I.; *for mail*, 31½ Forest St., Milford, Mass.

MILTON, Boston Section

HIBBARD, Thos. ('89), Retired; 4 Ridge Rd.
McINTYRE, Wm. S. (J'36), 13 Artwill St.
ORTLA, Fred'k L. ('27), 25 Belvoir Rd.

NATICK, Boston Section

GALE, Horace Bigelow ('86), Retired; 10 Highland St.

NEEDHAM, Boston Section

GREEN, Arthur B. ('22), Cons. Engr., 249 Harris Ave.
HADLEY, Roger W. (J'36), Draftsman, C. L. Berger & Sons, 70 Williams St., Boston; *for mail*, 44 Ellicott St., Needham.
MAGLATHLIN, Sydney A. ('21; '35), Engr. Inspr., London Guarantee & Accident Co., Ltd., Rm. 618, 141 Milk St., Boston; *for mail*, 41 Trueman St., Needham Heights.
MITCHELL, Donald H. (J'31), 1217 Great Plain Ave.
THOLL, John F. ('30), 18 Parkinson St.

NEW BEDFORD, Providence Section

DIRKSEN, Peter C., Jr. ('28; '32; '35), M. E., New Bedford Gas & Elec. Light Co., 693 Purchase St.
HATHAWAY, Lincoln B. (J'30), Engrg. & Maint., Continental Screw Co.; *for mail*, 134 Arnold St.
RIPLEY, Chas. B. (J'31), Treas., Island Airlines, Inc., Homer's Wharf, New Bedford, Mass.; *for mail*, Oyster Bay, L. I., N. Y.
WYRZYWALSKI, Stanley (J'30), Asst. Supvr., Morse Twist Drill & Mch. Co., Pleasant St.; *for mail*, 72 Division St.

NEWBURYPORT, Boston Section

ABBE, Roy H. ('15; '26; '35), Supt. of Mfg., Towle Mfg. Co., 260 Merrimack St.; *for mail*, 36 Woodland St.

NEWTON, Boston Section

CLARKE, Chas. L. ('82), Cons. Engr., 109 Oakleigh Rd.
HORST, C. A. ('24; '33; '35), Foreman, Raytheon Prod. Corp., 49 Chapel St.; *for mail*, 5 Winchester Rd.
HUTCHINSON, Wm. C. (J'33), Sales Engr., Boston Draft Control Co., 839 Beacon St., Boston; *for mail*, 20 Applegarth St., Newton.

NEWTON CENTRE, Boston Section

COLLINS, Bertrand R. T. ('91; '01), 72 Oxford Rd.

NEWTON HIGHLANDS, Boston Section

COFFIN, G. S. ('18; '35), 12 Wenham Rd.
PENNEY, Loren W. ('18), Retired; 213 Lincoln St.
RIEHL, Harmon B. ('24; '35), New Eng. Rep., Proctor & Schwartz, Inc., 212 Winslow Rd.

NORTH ADAMS, Western Massachusetts Section

CLARK, Walter W. ('30; '35), M. E., Sprague Specialties Co., 210 Beaver St.
HUNTER, Jas. D. ('94), Pres., Jas. Hunter Mch. Co.
JONES, Ernest E. ('24; '28; '35), Power & Elec. Engr., Arnold Print Wks., Marshall St.; *for mail*, 36 Beacon St.
RIDDLE, Herbert S. (J'31), Sprague Specialties Co., N. Adams; *for mail*, 278 Berkshire Ave., Springfield.
RIDLEY, Walter H. (J'33), 36 Cherry St.
SHIRLEY, John G. ('14; '22; '27), Ch. Engr., Arnold Print Wks., 42 Marshall St.; *for mail*, 116 Church St.

NORTH AMHERST, Western Massachusetts Section

HOWE, Chas. S. ('15), Pres. Emeritus, Case Sch. of Applied Sci., Cleveland, Ohio; *for mail*, N. Amherst, Mass.

NORTHAMPTON, Western Massachusetts Section

WHEELER, Chas. Hadley (J'33), M. E., Product Devel. Dept., Fisk Rubber Corp., Chicopee Falls; *for mail*, 20 Maple St., Northampton.

NORTH ANDOVER, Boston Section

McCLUNG, Jas M. (J'36), 135 High St.
ROCKWELL, Samuel F. ('12), Treas., Managing Dir., Davis & Furber Mch. Co.

NORTH ATTLEBORO, Providence Section

KIVLIN, Alfred P. ('21; '26), Valuation & Appraisal, 43 School St.

NORTH BILLERICA, Boston Section

STARBUCK, Geo. F. ('01; '23), Calculator, Mech. Dept., Boston & Maine R. R. Co., N. Billerica; *for mail*, 141 Weston St., Waltham.

NORTH DIGHTON, Providence Section

ROBERTSON, J. D. ('20; '26; '33), Plant Engr., Mt. Hope Finishing Co.

NORTH PLYMOUTH, Boston Section

ANTONIOTTI, Henry (J'33), 57 Main St.
BREWSTER, Ellis W. ('23; '35), Vice-Treas., Plymouth Cordage Co.
PRATT, Morton S. (J'34), Stationary Engr., Plymouth Cordage Co.; *for mail*, 429 Court St.

NORTH QUINCY, Boston Section

LEDUC, Richard J. ('29; '34; '36), Cons. Engr., Boston Gear Wks., Inc., Hayward Pl., N. Quincy; *for mail*, 44 Hamden Circle, Wollaston.
SCHUMB, Martin T. ('27), V. P., Charge Engrg., Boston Gear Wks., Inc., N. Quincy; *for mail*, 27 Garden St., E. Milton.
WILLIAMS, Edwin T. (J'36), 189 Atlantic St.

NORTH SCITUATE, Boston Section

NEWCOMB, Edw. C. ('13), Retired.

NORTON, Providence Section

CUTLER, Arthur E. ('10), Business Mgr., Wheaton College; *for mail*, Box 49.

NORWOOD, Boston Section

DEXTER, Chas. Francis (J'36), Order Dept. of Eng. Drawing Dept., Bethlehem Steel Corp., Howard St., Quincy; *for mail*, 93 Lincoln St. Norwood.
HOLTON, Adolphus, Jr. (J'36), 108 Cottage St.
PIERCE, Almon J. ('23), A. J. Pierce, Inc., 3 Cottage St.; *for mail*, 206 Vernon St.
RODGERS, Arthur C. (J'36), 342 Prospect St.

ORANGE, Western Massachusetts Section

DEXTER, Bayard P. ('20; '35), Pres., Gen. Mgr., Leavitt Mch. Co., 12 E. River St.

PALMER, Western Massachusetts Section

KING, Carl ('14), Plant Supt., Wickwire Spencer Steel Co.; *for mail*, 511 N. Main St.
WERME, Andrew P. ('23), M. M., Wickwire Spencer Steel Co.; *for mail*, 599 N. Main St.

PEABODY, Boston Section

McLAUGHLIN, Geo. E. ('20; '30), Engr. Design, Turner Tanning Mchy. Co., Walnut St.

PITTSFIELD, Western Massachusetts Section

ABBOTT, Chas. C. ('05), Managing Engr., Specialty Dept., Gen. Elec. Co., Woodlawn Ave.; *for mail*, 240—2nd St.
CHESNEY, Malcolm M. ('20; '25), Safety Engr., Gen. Elec. Co., 100 Woodlawn Ave.; *for mail*, 7 Kenilworth St.
COOPER, Eli G. (J'35), M. E., Charge Dept. & Sales, May Engrg. Co., 12 Adam St.; *for mail*, 46 Prospect St.
HURT, Wm. C., Jr. (J'29), Mfg. Engr's. Staff, Power Transformer Div., Gen. Elec. Co.; *for mail*, 119 Holmes Rd.
KELLY, John P. ('29), 30 George St.
LEWTHWAITE, Alfred L. ('18; '35), Mech. Designer, Bushing Eng. Dept., Gen. Elec. Co., 100 Woodlawn Ave.; *for mail*, 116 Edward Ave.
REINHARDT, Bryson R. (J'36), 31 Springside Ave.

PLYMOUTH, Boston Section

DAMON, John H. ('08; '10), Plant Engr., Plymouth Cordage Co., N. Plymouth; *for mail* 258 Court St., Plymouth.
MACKINNON, Chas. ('21; '26; '35), 6 Holmes Terrace.

QUINCY, Boston Section

FOX, Benj. ('23), Asst. Ch. Engr., Charge Design, Bethlehem Shipbldg. Corp., Ltd., Quincy; *for mail*, 5 Buckingham Rd., Wollaston.
PAIGE, Jas. F. ('17), 49 Whitney Rd.

READING, Boston Section

BAKER, Roy E. ('33), Gen. Air Brake Inspr., Boston & Maine R. R., 150 Causeway St., Boston; *for mail*, 31 Avon St., Reading.
IVES, C. Quincy ('29), Supt., Sherman Paper Products Corp., 156 Oak St., Newton Upper Falls; *for mail*, 132 Oak St., Reading.
TABER, Wentworth D. (J'31), Indus. Engrg. Dept., Simplex Wire & Cable Co., Sydney St., Cambridge; *for mail*, 1002 N. Main St., Reading.

THOMPSON, Glenn A. (J'31), Serv. Engr., N. Y. Air Brake Co., 420 Lexington Ave., New York, N. Y.; *for mail*, 37 Prescott St., Reading, Mass.
VAN STONE, Chas. ('14), Retired; 66 West St.
WYATT, Ernest B. ('23; '35), 32 Highland St.

REVERE, Boston Section

HORTON, Arthur M. (J'34), Sales Rep., Marchant Calculating Mch. Co., 216 Tremont St., Boston; *for mail*, 155 Endicott Ave., Revere.

SALEM, Boston Section

CHEPELEFF, Nickolas (J'34), 64 Forrester St.
KIMBALL, Jas. L. ('23), M. E., Ruggles Klingemann Mfg. Co., Salem; *for mail*, 10 Walnut, Danvers.
PELLETIER, Emile J. ('27; '35), Aero. Design Checker, Bell Aircraft Corp., 2050 Elmwood Ave., Buffalo, N. Y.; *for mail*, 79 Ocean Ave., Salem, Mass.

SANDWICH, Boston Section

DEARBORN, Wm. L. ('92; '17).

SHARON, Boston Section

McMAHON, Jerome B. ('31; '33), Mgr., Controller Div., Foxboro Co., Neponset Ave., Foxboro; *for mail*, 19 Huntington Ave., Sharon.

SHREWSBURY, Worcester Section

CARLSON, Hjalmar Gotfried (Non-Member), *A. S. M. E. Medallist*, '21; *Holley Medallist*, '24; 15 Water St.
STREETER, Claude O. ('15; '20), Cons. M. E., 508 Lake St.

SOMERVILLE, Boston Section

BARATTA, Henry E. (J'31), Asst. Hyd. Engr., Flood Control Study, U. S. Geol. Survey, Washington, D. C.; *home address*, 73 Park St., Somerville, Mass.
LANCAON, J. S. (J'32), Draftsman, Jerguson Gage & Valve Co., Somerville; *for mail*, 96 College Ave., Medford.
LIBBY, Malcolm ('02; '05; '09), Power Plant Engrg., 9 Winter Hill Circle.
PANZA, Jos. E. (J'36), 15½ Albion St.
SHERMAN, J. Francis (J'36), Jr. M. E., Maint., East. Gas & Fuel Associates, 201 Roland St., Everett; *for mail*, 11 Garfield Ave., Somerville.

SOUTH BRAINTREE, Boston Section

WHEAT, Oscar G. (J'30), Asst. Gen. Supt., Armstrong Cork Co.

SOUTHBRIDGE, Worcester Section

D'ARCY, Francis G. ('35), Asst. Supt., Am. Optical Co.; *for mail*, 53 Newell Ave.
GUILD, Julius (J'36), M. E., Prod. & Inspc., Am. Optical Co., Mechanic St.; *for mail*, 67 Coombs St.
GUNNING, Wm. A. ('36), Engr., Charge Design, Am. Optical Co., Mechanic St.; *for mail*, 103 Hartwell St.
LACROIX, Arthur J. ('14; '35), Pres., Charge Prod., Hyde Mfg. Co., 54 Eastford Rd.
MULLER, Otto ('33), Supt., Am. Optical Co., Mechanic St.; *for mail*, 251 Marcy St.
SUTHERLAND, Wm. H. (J'36), Time Study Man, Am. Optical Co., Southbridge; *for mail*, Sturbridge.

SPRINGFIELD, Western Massachusetts Section

BAILEY, Albert ('28), M. E., Mass Prod., United Am. Bosch Corp.; *for mail*, 825 Chestnut St.
BETTERLEY, Edw. W. (J'34), 25 Spencer St.
BOCCASILE, Graziano I. (J'35), 33 Cleveland St.
CHIRAS, David (J'35), Inspr., Westinghouse Elec. & Mfg. Co., Springfield; *for mail*, 915 Providence St., Whitinsville.
DUPEE, C. Frank ('21), Asst. to Ordnance Engr., U. S. Armory; *for mail*, 155 Bay St.
FRANKLIN, Benj. A. ('13), Indus. Engr., 95 State St.
FREER, Herbert L. (J'35), 130 Dunmoreland St.
GARRETSON, Henry C., Jr. (J'32), Apprentice Engr., Package Mchy. Co., Birnie Ave. & Medford St.; *for mail*, 122 Chestnut St.
HARTSHORN, Derrick S. ('21; '24), Cost Reduction Engr., Westinghouse Elec. & Mfg. Co., Page Blvd.; *for mail*, 24 Middlesex.
HOUGHTON, Wm. M. ('25; '34), Devel. Engr., Gilbert & Barker Mfg. Co.
JERVEY, Thos. M. ('23), Maj. Ord. Dept., U. S. A., Springfield Armory.
KRESSER, Leo ('22), Engr., United Am. Bosch Corp.; *for mail*, 114 Albermarle St.
LEE, Gorman M. (J'30), Tool Designer, Springfield Armory, Federal St., Springfield; *for mail*, 48 Eliot St., Jamaica Plain.
LEWIS, Alex. H. G., Jr. (J'34), Design Draftsman Spec. Mchy., A. G. Spalding & Bros., Chicopee; *for mail*, 160 Wellington St., Springfield.

MACCARTHY, Parker W. (J'31), 53 Jenness St.
MANGOLD, Rudolf ('27; '35), M. E., Charge Engrg., United Am. Bosch Corp., 3664 Main St., Springfield; *for mail*, 158 Woodmont St., W. Springfield.
MILLER, Henry A. (J'34), 223 Hancock St.
PEGLOW, Walter (J'28), M. E., Westinghouse Elec. & Mfg. Co., E. Springfield; *for mail*, 94 Riverdale St., W. Springfield.
RICHMOND, John L. (J'35), Engr., Diesel Injection Testing, United Am. Bosch Co., Springfield; *for mail*, 600 Broadway, Chicopee Falls.
SCHERNER, John ('17; '20), Mech. Supt., Fisk Rubber Corp.; Grove St. Chicopee Falls; *home address*, 127 Whitman St., Springfield.
SCOTT, Donald C. (J'34), M. E., Design & Constr. Ludlow Mfg. Co., Ludlow; *for mail*, 237 Bay St., Springfield.
SCOTT, Eugene W. (J'34), 54 Windemere St., E. Springfield.
SHIRLEY, Robt. ('06), Cons. Engr., 59 Kimberly Ave.
SHOEMAKER, Fred R. ('25; '31; '35), Ord. Engr., Springfield Armory, Armory Sq.; *for mail*, 149 High St.
SMITH, E. Lovell ('28), Ch. Engr., Package Mchy. Co., Springfield; *for mail*, 148 Colony Rd., Longmeadow.
STONEROD, Chas. H. ('25), Sales Engr., E. F. Houghton & Co., 240 W. Somerset St., Philadelphia, Pa.; *for mail*, Box 665, Springfield, Mass.
TAPP, Harry F. ('23; '29), Asst. to Pres., Gilbert & Barker Mfg. Co., Springfield; *for mail*, 129 Overbrook Rd., Longmeadow.
VAN NORMAN, Fred'k D. ('19), V. P., Van Norman Mch. Tool Co., 160 Wilbraham Ave.; *for mail*, 120 Clarendon St.
WALSH, Edw. R. ('30; '35), Branch Mgr., Gilbert & Barker Mfg. Co., Springfield; *for mail*, 100 Church St., W. Roxbury.

STOCKBRIDGE, Western Massachusetts Section

OSBORNE, Loyall A. ('15), V. P. (Retired), Westinghouse Elec. & Mfg. Co.; *for mail*, White Lodge.

STONEHAM, Boston Section

KLEINSCHMIDT, Robt. V. ('21; '29), 20 East St.
MIRICK, Geo. L. ('22), Sr. Engr., Constr. Div., Q. M. Corps, War Dept., U. S. A., Army Base, Boston; *for mail*, 3 Webster Court, Stoneham.

SWAMPSCOTT, Boston Section

D'ARCEY, Alfred C. (J'34), Engr., Charge Test. & Research, Mason-Neilan Regulator Co., 1190 Adams St., Boston; *for mail*, 16 Humphrey St., Swampscott.
HENDERSON, John R. (J'33), Turbine Engrg. Dept., Gen. Elec. Co., 920 Western Ave., W. Lynn; *for mail*, 25 Cedar Hill Terrace, Swampscott.
KOHL, Fred'k S. (J'34), 237 Humphrey St.
RANSOM, J. Frederick (J'35), Test Dept., Gen. Elec. Co., Schenectady, N. Y.; *for mail*, 237 Humphreys St., Swampscott, Mass.

TAUNTON, Providence Section

GEBHARD, Leslie N. (A'31), Secy., Treas., Noyes-perkins & Co., Inc.; *for mail*, 4 Silver St.
SIEKIERKA, Frank (J'31), 495 Whittenton St.
WALDRON, Everett H. ('20), M. E., Mt. Hope Finishing Co., N. Dighton; *for mail*, 228 Weir St., Taunton.
WARE, Walter C. ('20), V. P., Charge Engrg., Paragon Gear Wks., Inc., Cushman St.; *for mail*, 133 Winthrop St.

TUFTS COLLEGE, Boston Section

CHASE, Chas. H. ('02), Prof., Steam Engrg., Tufts College.
FARNHAM, Walter E. ('18; '35), Prof. Graphics, Head Dept., Engrg. Sch., Tufts College.
LEAVITT, Ernest E. (J'26), Asst. Prof. M.E., Engrg. Sch., Tufts College; *for mail*, 58 Outlook Dr., Lexington.

TURNERS FALLS, Western Massachusetts Section

MOODY, Herbert A. ('01; '05; '10), Hyd. Engr., West. Mass. Cos., 201 Devonshire St., Boston; *for mail*, 2 Ave. B, Turners Falls.
SLOMAN, Robt. A. (J'31), Designing Draftsman, Montague Mch. Co., Turners Falls; *for mail*, 307 Conway St., Greenfield.

WABAN, Boston Section

ABORN, Geo. Pennell ('89; '92), 25 Annawan Rd.
DERR, Thos. S. ('19; '35), Pres., Am. Steam Auto Co., Hawthorn St., Newton; *for mail*, 260 Quinobequin Rd., Waban.
ST. LAWRENCE, Leslie H. (J'32), 263 Waban Ave.

WAKEFIELD, Boston Section

FAIRBANKS, Frank L. ('13), 34 Stedman St.

WALPOLE, Boston Section

FISHER, David G. (J'31), 171 Spring St.
LAIRD, I. Lavren ('36), Mfg. Mgr., Bird Mch. Co., Neponset St.; *for mail*, 23 Mylod St.

WALTHAM, Boston Section

HAYES, John Schofield (J'32), 224 Lowell St.
KELLY, Erskine R. (J'34), 89 Galen St.
KING, Donald M. (J'35), Asst. Plant Mgr., Thompson, Weinman & Co., Inc., Turner St.
SMITH, Chas. F. (J'36), Wyman St.
WYNNE, John Thos. ('27; '35), Supt. Inspc., Waltham Watch Co., Crescent St.; *for mail*, 48 Bruce Rd.

WARE, Worcester Section

BRIGHAM, E. Edwin ('23), Plant Engr., Otis Co.; *for mail*, 31 Pleasant St.

WATERTOWN, Boston Section

CARROLL, Chas. H. (J'32), 26 Royal St.
CREAMER, Vincent A. (J'35), 113 Winsor Ave.
GALAHER, Francis B. ('20), Supt. Engrg., Hood Rubber Co.
GOUNARIS, Basil V. (J'36), 66 Morse St.
GRADE, Oscar W. ('18), 34 Sunnybank Rd.
HIGGINS, Edwin M. (A'30), New Eng. Mgr., Master Lubricants Co., Philadelphia, Pa.; *for mail*, 18 Hovey St., Watertown, Mass.
JENKS, Glen F. ('09; '14), Col., Ord. Dept., U. S. A., Commanding Officer; Watertown Arsenal.
ROOT, Ernest L. ('29), Sales Engr., Permutit Co., P. O. Box 66.

WELLESLEY HILLS, Boston Section

DEN HARTOG, J. P. ('29; '35), Assoc. Prof. Applied Mechanics, Harvard Univ., Pierce Hall, Cambridge; *home address*, 64 Fairbanks Ave., Wellesley Hills.
MIDDLETON, Percy H. ('94; '01), 22 Elm St.
SPOFFORD, Harry H. R. ('15; '22), 11 Windsor Rd.

WESTBORO, Worcester Section

McMAHON, Chas. M. (J'33), Maint. Engr., Westboro State Hosp.; *for mail*, 76 Milk St.

WEST BOYLSTON, Worcester Section

CARROLL, Elbert H. ('00), Retired; Prospect St.

WESTFIELD, Western Massachusetts Section

.DZIMA, Geo. R. (J'30), 65 E. Silver St.
'AMPBELL, Lester ('19), Mech. Supt., Charge Experiment & Research, Foster Mch. Co., S. Broad St.; *for mail*, 74 Franklin St.
YMAN, Wallace R. (J'29), Test Engr., H. B. Smith Co., Westfield; *for mail*, R. D. 1, Northampton.
'ADE, W. Morgan ('31; '35), Engr., Westfield State Sanatorium; *for mail*, P. O. Box 186.
'ALTON, Albert, Jr. (J'21), Plant Engr., Old Colony Envelope Co., Westfield; *for mail*, 40 Harvard St., Springfield.

WEST LYNN, Boston Section

LACK, Stanley B. (J'24), Engr., Turbine Dept., Gen. Elec. Co., 920 Western Ave., W. Lynn; *for mail*, 34 Otis St., Medford.
LOOMBERG, David J. ('25; '35), Research Engr., Steam Turbines, River Wks., Gen. Elec. Co., W. Lynn; *for mail*, 64 Fairmont Ave., Newton.
ROWN, Thos., Jr. ('30; '35), M. E., Charge Maint., Gen. Elec. Co., 920 Western Ave., W. Lynn; *for mail*, 35 Sewall St., Revere.
ICKERSON, Kenneth J. (J'33), Indus. Engr., Gen. Elec. Co., W. Lynn; *for mail*, 55 Blaney St., Swampscott.
ICKINSON, Edgar D. ('13), Engr., Charge Design, Gen. Elec. Co., 920 Western Ave., W. Lynn.
RICSON, Franklin R. ('25; '35), Designer, Turbine Engrg. Dept., River Wks., Gen. Elec. Co.
DDSCHALL, Milton G. (J'27), M. E., Gen. Elec. Co., 920 Western Ave., W. Lynn; *for mail*, 11 Piedmont St., E. Lynn.
DLDSBURY, John ('36), M. E., Bldg. 64, River Wks., Gen. Elec. Co., W. Lynn; *for mail*, 32 Atkins Ave., Lynn.
AKE, Robb A. ('28; '33), Mgr., Contract Serv. Dept., Gen. Elec. Co.
DLT, K. M. ('21), Asst. to Designing Engr., Turbine Dept., River Wks., Gen. Elec. Co., Western Ave.
HNSON, Wistar W. ('32), Research Engr., Steam Turbines, River Wks., Gen. Elec. Co.
NG, Harold M. ('14; '35), Asst. Engr., Steam Turbine Engrg. Dept., Gen. Elec. Co., 920 Western Ave., W. Lynn; *for mail*, 90 Walker Rd., Swampscott.
MOSS, Sanford A. ('03), Research Engr., Thomson Research Lab., Gen. Elec. Co., 920 Western Ave.
PHILLIPS, Edmund Merrill ('17; '35), Turbine Designer, Gen. Elec. Co., 920 Western Ave.
POLLARD, Edw. V. (J'21), Asst. Engr., Gen. Elec. Co., W. Lynn; *for mail*, 64 Atlantic St., Lynn.
ROBERTS, Edw. H. (J'36), Student Engr., Turbine Tests, River Wks., Gen. Elec. Co., W. Lynn; *for mail*, 24 Baker St., Lynn.
THOMSON, Elihu (H'30), Cons. Engr., Dir. Research Lab., River Wks., Gen. Elec. Co.
WARNER, Donald F. ('26; '35), Asst. Engr., River Wks., Gen. Elec. Co., W. Lynn; *for mail*, 196 Aspen Rd., Swampscott.

WEST MEDFORD, Boston Section

JEWETT, Geo. L. (J '34), Design, Scien. Dept., Bethlehem Shipbldg. Corp., Ltd., Fore River Plant, Quincy; *for mail*, 97 Playstead Rd., W. Medford.

WEST NEWTON, Boston Section

PETERSON, T. Edwin ('30), Asst. M. E., Equip. Engrg. Dept., Boston & Albany R. R., Rm. 321, S. Sta., Boston; *for mail*, 857 Watertown St., W. Newton.
SHEPARD, Fred'k J., Jr. ('17; '29), Treas., Lewis-Shepard Co., 125 Walnut St., Watertown; *home address*, 67 Berkeley St., W. Newton.

WESTON, Boston Section

CAMMANN, Oswald, Jr. (J'22), Pres., Treas., Cammann Mfg. Co., Inc., P. O. Box 163, Waltham; *for mail*, 235 Conant Rd., Weston.

WEST SOMERVILLE, Boston Section

FIELD, David Porter (J'24), 103 College Ave.
MacNAUGHTON, Edgar ('15; '21), Prof. M. E., Tufts College, Medford; *for mail*, 162 Curtis St., W. Somerville.

WEST SPRINGFIELD, Western Massachusetts Section

KIBBE, Harlow E. (J'32), Refrig. Engr., Westinghouse Elec. & Mfg. Co., Page Blvd., E. Springfield; *for mail*, 11 Park Ave., W. Springfield.
LINDAHL, Fred M. (J'25), Devel. Engr., Gilbert & Barker Mfg. Co., Springfield; *for mail*, 28 Worthy Ave., W. Springfield.
WHOLEAN, Geo. R. ('19; '35), Ch. Engr., Strathmore Paper Co.; *for mail*, 49 Beauview Terrace.

WESTWOOD, Boston Section

KINRAIDE, Robt. (J'33), Box 165.

WHITINSVILLE, Worcester Section

BALL, Lawrence R. ('28; '35), Ch. Power Engr., Whitin Mch. Wks.; *for mail*, 111 East St.
BANFIELD, Frederic E., Jr. ('09; '18), Whitin Mch. Wks.

WHITMAN, Boston Section

BENSON, Harry F. ('20), 110 Harvard St.

WINCHENDON, Worcester Section

HAWES, Austin W. ('27), Engrg. Dept., Baxter D. Whitney & Son, Inc.; *for mail*, 103 Pleasant St.
MAY, Elliot D. (J'20), Designer, Baxter D. Whitney & Son, Inc., Elm St.; *for mail*, 244 Front St.
WHITNEY, Wm. M. (A'86), Pres., Baxter D. Whitney & Son, Inc.

WINCHESTER, Boston Section

COLE, Fred Baker ('11), 196 Parkway.
DAWES, Herbert N. ('02), Insulation Consultant, Ehret Magnesia Mfg. Co., Valley Forge, Pa.; *for mail*, 7 Ravenscroft Rd., Winchester, Mass.
GAUM, Albert F. ('21; '24; '35), 176 Mystic Valley Pkwy.
MERCIER, Stanley M. ('36), 238 Highland Ave.

WINTHROP, Boston Section

KELLER, Ralph L. (J'34), M. E., Design of Counters, Waltham Watch Co., Crescent St., Waltham; *for mail*, 157 Brewster Ave., Winthrop.
LYNCH, J. E., Jr. ('21; '35), 168 Bartlett Rd.
PERRY, Stewart S. (J'27), Sales Engr., Worthington Pump & Mchy. Corp., 10 High St., Boston; *home address*, 36 Pleasant St., Winthrop.

WOBURN, Boston Section

KHIRALLA, Tofa Wm. (J'32), Asst. to Engr., Mass. Gear & Tool Co., Woburn; *for mail*, 79 E. Brookline St., Boston.

WOLLASTON, Boston Section

BLAKE, Arthur Henry ('20; '26; '35), New Eng. Rep., G. S. Blakeslee & Co., 1900 S. 52nd St., Cicero, Ill.; *for mail*, 24 Merrymount Ave., Wollaston, Mass.
BRIGGS, Leroy E. ('11; '14; '20), 347 Highland Ave.

WOODS HOLE, Providence Section

MONTGOMERY, Thos. R. (J'32).

WORCESTER, Worcester Section

ABADJIEFF, Ivan V. (J'29), Ch. Engr., Putnam Co., 1053 S. Bridge St.; *for mail*, P. O. Box 293.
ALLEN, Chas. M. ('01; '03; F'36), Manager, '28-'31; Vice-President, '31-'33; *Worcester Reed Warner Medallist*, '36; Prof. Hyd. Engrg., Worcester Poly. Inst.
BALCOME, Saml. Emory ('20), Power Engr., Graton & Knight Co., 356 Franklin St.; *for mail*, 622 Pleasant St.
BARNES, Wm. O. ('08), Cons. Engr., 630 Pleasant St.
BARRY, Edw. H. ('31), Gen. Sales Mgr., Riley Stoker Corp.
BEAMAN, P. Alden ('15; '35), Mgr., Wire Mchy. Dept. Morgan Constr. Co., 15 Belmont St.
BELMONT, Robt. I. (J'33), Supt. Charge Prod., L. Hardy Co., 9 Mill St.; *for mail*, 135 Grand View Ave.
BETH, Hugo W. H. ('12), Wks. Mgr., Abrasive Div., Norton Co., 1 New Bond St.; *for mail*, 25 Dean St.
BETH, Walter F. (J'36), Jr. Engr., Norton Co.; *for mail*, 25 Dean St.
BLACKBURN, Arthur H. ('94), Asst. Sales Mgr., Jones Stoker Div., Riley Stoker Corp., 9 Neponset St.; *for mail*, 418 Lovell St.
BLOOD, Harold L. ('26), 25 Metcalf St.
COOK, Arnold M. (J'29), Engr., Plants Engrg. Dept., Norton Co., 1 New Bond St.; *for mail*, 20 Summerhill Ave.
CORSINI, Umbert F. (J'33), 239 Lincoln St.
CRAIG, Ollison ('21), Mgr., Engrg. Dept., Riley Stoker Corp., 9 Neponset St.; *for mail*, 245 Burncoat St.
CRANE, Howard P. ('28; '32), Car Designer, Pullman-Stand. Car Mfg. Co.; *for mail*, 9 Michigan Rd.
DANIELS, Clarence W. ('16; '21), Plant Engr. & Dir., Norton Co., 1 New Bond St.; *for mail*, 9 Metcalf St.
DANIELS, Fred H. ('18; '26), Pres., Riley Stoker Corp., 9 Neponset St.; *for mail*, 190 Salisbury St.
DAVEY, Geo. W. ('25; '35), Gen. Supt., Riley Stoker Corp., 9 Neponset St.
DENNEN, Walter B. ('20; '26; '35), Instr. Math. & Trade Science, Worcester Boys Trade Sch.; *for mail*, 27 Dover St.
DOWD, Stanley B. (A'29), Sales Mgr., Leland-Gifford Co.
DOWNING, Donald G. (J'33), Instr. M. E., Worcester Poly. Inst., Boynton St.
DOWS, Harold W. ('20; '26; '35), Asst. Prof. M. E., Worcester Poly. Inst.; *for mail*, 47 Barnard Rd.
EARLE, Ralph ('26), Pres., Worcester Poly. Inst.
EATON, Frank L., Jr. (J'33), Asst. Installations Engr., Air Conditioning, W. H. Sawyer Lumber Co., 46 Lincoln St.; *for mail*, 52 William St.
ELLIOTT, Edw. ('21), Asst. Prin. Engr., Pullman Stand. Car Mfg. Co., 27 Mountain St.; *for mail*, 6 Devens Rd.
ENDICOTT, George ('15; '25), Stonehouse.
EWING, Thos. H. (J'20), Asst. Ch. Draftsman, Crompton & Knowles Loom Wks.; *for mail*, 6 Northridge St.
FAIRFIELD, Howard P. ('01), Prof. Emeritus, Worcester Poly. Inst., Boynton St.; *for mail*, 30 Boynton St.
FARQUHAR, Melville Taylor (J'36), M. E., Draftsman, Riley Stoker Corp., 9 Neponset St.; *for mail*, 80 Forest St.
FULLER, Geo. F. ('20), M. E., Chmn. Bd., Wyman-Gordon Co., 105 Madison St.; *for mail*, 15 Massachusetts Ave.
FURMAN, Louis J. (J'33), Draftsman, Norton Co., New Bond St.; *for mail*, 27 Brantwood Rd.
GIFFORD, Albert J. ('03; '31), Treas., Leland-Gifford Co., 1025 Southbridge St.
GILLETT, Chas. E. ('13; '21), Ch. Inspr., Norton Co., 1 New Bond St.; *for mail*, 4 Bay State Rd.
GINSBURG, Jacob ('17; '24; '27), Indus. Engr., S. Wks., Am. Steel & Wire Co.; *for mail*, 3 Intervale Rd.
GOW, Ralph F. ('26; '33; '35), Supt., Norton Co., 1 New Bond St.
HENRICKSON, John A. (J'33), Foreman, Charge Cold Rolling, Am. Steel & Wire Co., 94 Grove St., Worcester; *for mail*, 33 Chapin Rd., Holden.
HIGGINS, Aldus C. ('16), Pres., Gen. Mgr., Norton Co., New Bond St.
HIGGINS, John W. ('02; '13), Pres., Treas., Worcester Pressed Steel Co., 100 Barber Ave.
HILDEBRANT, Bertram A. ('25), Indus. Engr., Head Methods Dept., Norton Co., 1 New Bond St.; *for mail*, 44 Indian Hill Rd.

HITCHCOCK, John H. (J'31), Engr., Morgan Constr. Co., 15 Belmont St.
HOOPER, Leslie J. (J'29), with Prof. C. M. Allen, Worcester Poly. Inst.
HOWARD, Clifton P. ('24), Supt., Charge Prod., Maint. & Design, Rockwood Sprinkler Co., 38 Harlow St.; *for mail,* 18 Davidson Rd.
HOWE, Jas. F. ('15), Ch. Wire Rope Engr., Am. Steel & Wire Co., 94 Grove St.; *for mail,* 12 Burgess Rd.
HOYT, Albert J. ('16; '26), Asst. Mgr., Oper. Dept., Am. Steel & Wire Co., 94 Grove St.; *for mail,* 96 Commodore Rd.
HUBBARD, Clyde W. (J'31), Hyd. Engr. & Instr., Worcester Poly. Inst.; *for mail,* 35 Marland Rd.
JEPPSON, Geo. N. ('13), V. P., Treas., Norton Co., New Bond St.
KAVEN, Moses B. ('91), V. P., Cons. Engr., United Shoe Mchy. Corp., 140 Federal St., Boston; *for mail,* 10 Germain St., Worcester.
KENDALL, H. Clayton ('30), V. P., Rockwood Sprinkler Co., 38 Harlow St.; *for mail,* 32 Buckingham St.
KING, John A. ('25; '35), Sales Engr., Carborundum Co., Perth Amboy, N. J.; *for mail,* 7 Clearview Ave., Worcester, Mass.
KING, Vernon C. ('18; '24), Industrial Engr., Wickwire Spencer Steel Co., 56 Sterling St., Clinton; *for mail,* 20 Englewood Ave., Worcester.
KOLB, Robt. P. ('26; '30), Prof. Heat-Power Engrg., Worcester Poly. Inst.
KOWAL, Walter J. (J'34), 157 Perry Ave.
LANGE, Forrest Fay ('24; '25; '29), V. P., Charge Engrg., Fridgaite Associates, Inc., 49 Federal St., Boston; *for mail,* Slater Bldg., Worcester.
LARSON, C. Wm. ('23; '32), Instr. M. E., Worcester Poly. Inst., Worcester, Mass.; *for mail,* 524 St. Louis Ave., Rockford, Ill.
LARSSON, Thure L. F. ('05), M. E., Norton Co., 1 New Bond St.
LATHAM, Harry M. ('08), Ch. Engr., Crompton & Knowles Loom Wks.
LOFTUS, J. J. ('17; '35), 91 Stafford St.
MacCULLOUGH, Gleason H. ('21; '26; '30), Prof. Engrg. Mechanics, Worcester Poly. Inst.
MACKLIN, Ralph W. ('30), M. E., Morgan Wks., Wickwire Spencer Steel Co., 1 New Bond St.; *for mail,* 87 Whitmarsh Ave.
MARTIN, Dana West (J'35), Draftsman, Detailer, Mch. Div., Norton Co., 1 New Bond St., Worcester; *for mail,* R. F. D., Box 68, Stow.
McCASLIN, Stanley N. ('29; '30), Asst. to Ch. Engr., Crompton & Knowles Loom Wks., 93 Grand St.; *for mail,* 84 Brandon Rd.
MERKT, Gustav A. ('08; '18), Mgr., Combustion Control Dept., Morgan Constr. Co., 15 Belmont St.
MERRIAM, Kenneth G. ('23; '30; '35), Asst. Prof. Aero. Mechanics, Worcester Poly. Inst.
MISENER, Carroll C. (J'34), Asst. to Foreman, Rubber Wheel Dept., Norton Co., New Bond St.; *for mail,* 702 W. Boylston St.
MORGAN, Paul B. ('91; '00), Pres., Morgan Constr. Co., 15 Belmont St.
NAUGHTON, Frank U., Jr. (J'29), Sales Engr., Hyatt Roller Bearing Co., 983 Pleasant St.
NIKOLOFF, Subbo ('29), V. P., Leland-Gifford Co., Worcester, Mass.; *for mail,* 488 Pomfret St., Putnam, Conn.
OBER, Philip L. (J'36), M. E., Maint. Dept., Graton & Knight Co., 356 Franklin St.; *for mail,* 35 May St.
PALMER, Albert ('23; '34), Asst. to Gen. Mgr., Crompton & Knowles Loom Wks., 93 Grand St.
PEIX, C. H. (J'36), Asst. to Prod. Engr., Norton Co.; *for mail,* 15 Randolph Rd.
PESKIN, Leonard C. (J'34), Research M. E., Charge Design, Am. Steel & Wire Co., 2 Kansas St.
POMEROY, G. M. (J'19), Sales Mgr., Matthews Mfg. Co., 104 Gold St.
PRESCOTT, Perley R. ('18), 148 Lincoln St.
PRICE, M. Lawrence (J'31), Instr. M. E., Worcester Poly. Inst.
PUTNAM, Arthur D. (A'17), M. E., Maint., Worcester Elec. Light Co., 37 Harvard St.
RAMSEY, Webster K. ('22; '28; '35), Engr., U. S. Envelope Co.; *for mail,* 75 Grove St.
READ, Carleton A. ('93; '00), Cons. Engr., 15 Hackfeld Rd.
REED, Chester T. ('06; '16), Secy., Reed & Prince Mfg. Co., Duncan Ave.; *for mail,* 354 Salisbury St.
REED, E. Howard ('05; '13), Pres., Treas., Reed Small Tool Wks., 237 Chandler St.; *for mail,* 33 Wildwood Ave.
REID, Alexander ('18), Mgr., Holyoke Mch. Co., 81 Thomas St.; *for mail,* 56 Fruit St.
ROBBINS, Wm. F. ('20; '35), Plant Engr., Charge Maintenance & Development, Graton & Knight Co., 356 Franklin St.; *for mail,* 29 Laconia Rd.
ROCKWOOD, Geo. I. ('91; F'36), Manager, '03-'06; Vice-President, '24-'25; Life Member; 2 Military Rd.
ROYS, Francis W. ('21), Prof., Head of M. E. Dept., Worchester Poly. Inst.
ST. JOHN, Stuart B. ('29; '35), New Bond St.; *for mail,* 7 Harvard St.
SEARLE, Wilbur C. ('09; '21; '35), M. E., Design & Maint., Leland-Gifford Co., 1025 Southbridge St.; *for mail,* 1199 Pleasant St.
SHEPERDSON, John W. ('08; '11), V. P., Morgan Constr. Co., 15 Belmont St.
SMITH, Alton Lincoln ('04), Asst. to Pres.; Prof. Draw. & Mch. Design, Worcester Poly. Inst., Boynton St.
SMITH, Eric Hooper (J'32), Sales Engr., Riley Stoker Corp., 9 Neponset St.; *for mail,* 20 Edgewood St.
SNOW, Warren S. (J'34), Asst. Exper. Div., Heald Mch. Co., 10 New Bond St.; *for mail,* 17 Barnard Rd.
SPAULDING, Ellis R. (J'32), Instr., Worcester Poly. Inst., Boynton St.; *for mail,* 47 Wachusett St.
SUTPHEN, Walter A. ('23; '31; '35), Dist. Power Engr., New Eng. Power Service Co., 11 Foster St.
SYLVESTER, Asher E. (J'36), Tester, Am. Steel & Wire Co., 94 Grove St.; *for mail,* 179 Pleasant St.
TAYLOR, Irving A. ('21), Mch. Designer, Mch. Div., Norton Co.; *for mail,* 8 Intervale Rd.
TOWNSEND, A. Francis, Jr. (J'32), Demonstrator, Heald Mch. Co., New Bond St.; *for mail,* 3 Waconah Rd.
TREAT, Franklin G. (J'30), Ch. Engr., Fuel Burning Equip. Div., Riley Stoker Corp., 9 Neponset St.; *for mail,* 48 Brownell St.
TURNER, Chas. H. ('05; '17), Principal Engr., Pullman-Stand. Car Mfg. Co., 27 Mountain St. W.; *for mail,* 5 Waconah Rd.
WECHSBERG, Otto ('21), Pres., Gen. Mgr., Coppus Engrg. Corp., 344 Park Ave.; *for mail,* 1006 Main St.
WELLMAN, B. Leighton (J'30), Instr. M. E., Worcester Poly. Inst.; *for mail,* 195 Park Ave.
WILLIAMSON, Chas. W. ('20; '35), Draftsman, Morgan Constr. Co., 15 Belmont St,. Worcester; *for mail,* Box 341, N. Grafton.
WOOD, Russell H. (J'35), 28 Buckingham Rd.
ZARTARIAN, Ervin (J'34), Engrg. Clerk, Am. Steel & Wire Co., 767 Millbury St.; *for mail,* 105 Summer St.

MICHIGAN

ADRIAN, Detroit Section

OLIVER, Edd C. ('02; '26), Mgr., Oliver Instrument Co.

ALLEGAN, Peninsula Section

KELLOGG, Chas. W. ('28), 343 Cutler St.

ALPENA, Detroit Section

MORSE, Arley E. (J'34), Engr., Charge Design, Huron Indus. Co.; *for mail,* 521 N. 2nd Ave.

ANN ARBOR, Detroit Section

AIREY, John ('15; '19), Life Member for Distinguished Service, '23; V. P. & Gen. Mgr., King Seeley Corp., 311 Maynard St.; *for mail,* 2009 Washtenaw Ave.
ANDERSON, Henry Clay ('12), Head of M. E. Dept., Univ. of Mich., 221 Engrg. Bldg.; also Cons. Engrg.
BOSTON, Orlan Wm. ('20; '23), Dir. & Prof., Metal Processing Dept., Univ. of Mich.
BOWEN, Frank M. (A'26), Mem. Firm, Jensen, Bowen & Farrell, 209 Michigan Theatre Bldg.
BURSLEY, Col. Jos. A. ('06; '10), Prof. M. E. & Dean of Students, Univ. of Mich.; *for mail,* 2107 Hill St.
COLLINS, F. Alton ('10; '17; '35), Sales Dept., Hoover Ball & Bearing Co., Hoover Ave.; *for mail,* 1705 Shadford Rd.
CUTHBERT, Ivan N. ('28), Partner, Cuthbert & Cuthbert, 327 E. Huron St.
DIXON, John J. (J'33), Valuation Engr., Jensen, Bowen & Farrell, Michigan Theatre Bldg., Ann Arbor, Mich.; *for mail,* 234 Garside St., Newark, N. J.
DOUGLAS, Donald C. ('23; '30; '35), 1320 W. Huron St.
EVERETT, Franklin L. (J'26), Asst. Prof. Engrg. Mechanics, College of Engrg., Univ. of Mich.
FINCH, Frank R. ('20), Assoc. Prof. Mechanism & Engrg. Drawing, College of Engrg., Univ. of Mich.; *for mail,* 1619 S. University Ave.
FREMONT, W. O. ('32), Asst. Research & Testing Engr., Mich. State Highway Dept., E. Engrg. Bldg.; *for mail,* 1125 Olivia Ave.
GILBERT, W. W. (J'35), Instr. in Metal Processing, Univ. of Mich., 2047 E. Engrg. Bldg.
GOOD, Chas. W. ('20; '25), Assoc. Prof. M. E. & Asst. Dir. Engrg. Research, Univ. of Mich., 2038 E. Engrg. Bldg.
HAWLEY, Ransom S. ('16), Prof. M. E., Univ. of Mich., 333 W. Engrg. Bldg.
KEELER, Hugh E. ('12; '19; '22), Prof. M. E., Univ. of Mich., 231 W. Engrg. Bldg.; *for mail,* 728 Onondaga St.
MAULBETSCH, John L. (J'35), Research Engr., Univ. of Mich.; *for mail,* 520 E. Jefferson St.
MILLER, Henry W. ('12; '21), Prof. & Head Dept., Mechanism & Engrg. Drawing, Univ. of Mich.
SADLER, Herbert C. ('28), Dean, College of Engrg., Univ. of Mich.
SELLEW, Wm. Hamilton ('13), Eavescote, Hill & Berkshire Rds.
SPOONER, C. W., Jr. (J'34), Instr. M. E., Univ. of Mich.
STALKER, Edw. A. ('30), Prof. Aero. Engrg., Univ. of Mich., 302 E. Engrg. Bldg.
STEPHENS, John Harris (J'35), Univ. of Mich. Graduate School, Ann Harbor, Mich.; *for mail,* 3103 Hamilton Ave., Baltimore, Md.
THOMPSON, Milton J. ('31; '35; '35), Asst. Prof., Dept. Aero Engrg., Univ. of Mich., B-304 E. Engrg. Bldg.
WHITE, Albert E. ('23), Prof. Metal. Engrg., Dir. Dept. of Engrg. Research, Univ. of Mch., 2038 E. Engrg. Bldg.

BATTLE CREEK, Peninsula Section

BANGHART, Lee E. ('21; '25; '35), Asst. Ch. Engr., Union Steam Pump Co.; *for mail,* 24 Sherman Rd.
BIRD, John C. ('10), M. E., Union Steam Pump Co.; *for mail,* 24 E. Columbia Ave.
BOHN, Robt. G. ('16; '24; '28), M. E., Charge Power, Constr. & Maint., Mich. Carton Co.
BROWN, Harry Wheeler ('09; '26), Plant Mgr., Post Products Div., Gen. Foods Corp.; *for mail,* 46 Elizabeth St.
BURROWS, Robt. J. ('14), Pres., Clark Tructractor Co.
DEAN, Edmund W. ('05), Cons. Engr., Duplex Ptg. Press Co.
GRIMMETT, Elmer J. ('26; '32; '35), Asst. Plant Engr., Post Products Div., Gen. Foods Corp.
ORDWAY, Earl P. ('14; '17), V. P. & Treas., Union Steam Pump Co.; *for mail,* 151 Emmett St.
STACKHOUSE, Howard L. (J'22), Maint. Engr., Post Prods. Div., Gen. Foods Corp.; *for mail,* 105 Chestnut St.

BAY CITY, Detroit Section

CURTISS, Chas. B. ('15; '23), Prop., Bay City Fdy. & Mch. Co., 1509 S. Water St.; *for mail,* 924 Center Ave.
JACOB, Brent C. ('22), E. E. & M. E., Indus. Brownhoist Corp., 135 Washington Ave.; *for mail,* 714—5th Ave.
McMANMON, Jos. C. (J'31), Refrig. Engr., Kolb Brewing Co., 603 Germania St.; *for mail,* 260 N. Van Buren St.
TERRILL, Franklin E. ('20; '35), Asst. Engr., Indus. Brownhoist Corp.; *for mail,* 2001 Center Ave.

BELDING, Peninsula Section

ALLEN, John D. (J'34), Factory Supt. & Pur. Agt., Metal Glass Products Co.; *for mail,* 704 Bridge St.

BIRMINGHAM, Detroit Section

FREMONT, Elmer G. (A'21), V. P., Gen. Mgr., Emerson Engrs., 30 Rockefeller Plaza, New York, N. Y.; *for mail,* 931 Fairfax Ave., Birmingham, Mich.
GOODNOW, Geo. N. ('31; '35), 2168 Yorkshire Rd.
KELLER, Emil E. ('94; F'36), Vice-President, '13-'15; Pres., Stand. Screw Products Co., 2559 Bellevue Ave., Detroit; *for mail,* P. O. Box 205, Birmingham.

BLOOMFIELD HILLS, Detroit Section

HAMMOND, Frederick M. (J'33).

CADILLAC, Peninsula Section

PETRIE, G. Rollo ('26; '29), Commer-Diggins Bldg.; *for mail,* 124 Spruce St.

CALUMET

WILLIAMS, Howard Edw. ('95; '04), Ch. Draftsman, Charge Design, Calumet & Hecla Consltd. Copper Co.

COLDWATER, Toledo Section

MURRAY, Wm. F. ('22; '31), Gen. Supt. & Pur. Agent, Wolverine Portland Cement Co.
REIGHARD, R. H. (J'34), 64 Hull St.

DEARBORN, Detroit Section

BAILEY, Delmas F. (J'29), 143 Tannahill.
MULLEN, Bernard J. ('36), Ch. Plant Engr., Dept. of Water Supply, City of Detroit, 8300 Warren Ave. W., Dearborn; *for mail,* 17174 Pennington Dr., Detroit.

SEICHTER, Frank R. (J'31), Maint. Engr., Ford Motor Co., Dearborn; *for mail*, 10286 Nardin Ave., Detroit.
SLEEMAN, Earl C. ('18; '30), Ch. Engr., Detroit Seamless Steel Tubes Co., Warren & Wyoming Aves.; *for mail*, 7232 Kingsley Ave.

DETROIT, Detroit Section

ADAMASZEK, John (J'36), 2031 Carpenter Ave.
ADAMS, Lyman D. ('17, '24), Gen. Mgr., Barnes-Gibson-Raymond, 6400 Miller Ave.
ALDEN, Carroll R. ('27), Research Engr., Ex-Cell-O Aircraft & Tool Corp., 1200 Oakman Blvd.
ALT, W. O. (J'35), Am. Blower Corp., 6000 Russell St.
ANDERSON, Ernest E. (J'20), Wks. Mgr., Charge Mfg., Goddard & Goddard Co., 12280 Burt Rd.
ARMOUR, Jas. W. ('20; '25; '30), Dist. Mgr., Riley Stoker Corp., Foot of Walker St.; *for mail*, 2515 Chicago Blv.
ASHER, Lester J. (J'36), Draftsman, Hudson Motor Car Co.; *for mail*, 2966 Dickerson Ave.
BAITS, Stuart G. ('18; '30), Ch. Engr., Hudson Motor Car Co.; *for mail*, 1009 Bishop Rd., Grosse Point Park.
BALDOCK, Fred C. (J'29), Staff Exec., Amplex Div., Chrysler Corp., 7100 Lynch Rd.; *for mail*, 1605 Collingwood.
BALDWIN, Harrison P. (J'36), 2267 W. Grand Blvd.
BANCROFT, Nicholas (J'35), Student Engr., Chrysler Corp., Highland Park.
BARTHEL, Oliver E. ('21), Cons. M. E., 2324 Dime Bank Bldg.
BARTHOLOMEW, EARL ('30; '35), Dir. Engr. Lab., Ethyl Gasoline Corp., 723 E. Milwaukee Ave.
BATEMAN, Thos. P. ('30; '35), Combustion Engr., Consolidation Coal Co., 2432 Buhl Bldg.; *for mail*, 16246 Kentucky Ave.
BATIE, Jos. E. ('28), M. M., Kelsey-Hayes Wheel Corp., 3600 Military Ave.
BAUM, Robt. F. (J'30), Engrg. Asst., Mich. Bell Tel. Co., 1365 Cass Ave.; *for mail*, 10401 E. Jefferson.
BEAUMONT, Jay C. ('18; '25), Prod. Engr., Sherman Corp., 1114—1st Natl. Bank Bldg.; *for mail*, 1220 Beaconsfield Ave., Grosse Pointe.
BEEDLE, Arthur K. (J'25), Plant Engr., M. E., Charge Maint., Aluminum Co. of Am., 3311 Dunn Rd.
BEERS, Royce L. ('14; '30), V. P., Charge Engrg., Detroit Stoker Co., Detroit; *for mail*, 345 Arlington Rd., Birmingham.
BENJAMIN, Max W. (J'31), Engr., Engrg. Div., Detroit Edison Co., 2000—2nd Ave.; *for mail*, 13217 Marlowe.
BERNITT, Elmer W. (J'33), Shop Engr., Plymouth Motor Corp., Mt. Elliott & Lynch Rd.; *for mail*, 2487 Baldwin Ave.
BEUKEMA, Leslie V. (J'34), Research Engr., Detroit Steel Products Co., 2250 E. Grand Blvd.
BEYER, Benjamin W., Jr. (J'21), Beyer Mchy. Co., 1347 Book Bldg.
BIGELOW, Frank B. ('07), Pres., Gen. Mgr., Bigelow-Liptak Corp., 2842 W. Grand Blvd.
BJERRE, Folmar ('27; '35), Sales Engr., Charge Engrg., J. N. Fauver Co., 91 Selden St.; *for mail*, 3765 W. Philadelphia St.
BLACK, Rowland J. (J'34) 4143—3rd Ave.
BOUTON, Geo. I. ('01; '04), Sales Engr., D. P. Brown & Co., 1440 Park Pl.; *for mail*, 2926 Baldwin Ave.
BOWER, Raymond G. ('21; '26; '35), Mech. Draftsman, Burroughs Adding Mch. Co.
BOYNTON, W. S. ('17; '35), Planning Dept., Constr. Engrg. Div., Fisher Body Div., Gen. Motors Corp.; *for mail*, 8616—2nd Ave.
BRADLEY, Jas. H. ('21; '35), Engr., Charge Design, Holcroft & Co., 6545 Epworth Blvd.
BREER, Carl ('12; '25), Exec. Engr., Chrysler Corp., 341 Massachusetts; *for mail*, 15600 Windmill Pointe Dr., Grosse Pointe.
BRENNAN, Wm. E. ('23; '26; '35), Inspc., Indus. Power, Detroit Edison Co., 2000—2nd Ave.; *for mail*, 4387 Pingree Ave.
BRISCOE, Ralph ('29), M. E., Plant Opera. & Maint., Detroit Edison Co., 2000—2nd Ave., Detroit; *for mail*, 1925 Church Place, Trenton.
BROCK, Clarence A. ('13; '20; '26), Registered M. E., 1545 Glynn Court.
BRUHL, Paul C. (J'31), 171 Ford Ave., Highland Park.
BUMGARDNER, Harvey E. ('30; '35), Engr., Research Dept., Detroit Edison Co., 2000—2nd Ave.
CARLIN, Jos. A. ('32), Gen. Mgr., Hutto Mch. Div., Carborundum Co., 515 Lycaste Ave.; *for mail*, 1220 Whittier Rd., Grosse Pointe Park.
CARTER, Wilber Albert ('20; '35), Tech. Engr. of Power Plants, Detroit Edison Co., 2000—2nd Ave.
CHAMPNEY, Ralph Preston ('16; '35), V. P., Mitchell & Smith, Inc., 9469 Copeland Ave.
CHEEVER, Paul ('21), 1557 Virginia Park.
CLADE, Robt. ('19; '35), Engr., Charge Prod., Am. Car & Fdy. Co., 5718 Russell St.; *for mail*, 119 Burlingame Ave.
CLAUSS, Julius A. ('28), Ch. Engr., Great Lakes Steel Corp., Ecorse; *for mail*, 17587 Birchcrest Dr.
CLEMENS, Wilson F. ('22; '35), Engr., Charge Furnace Design, Great Lakes Steel Corp., Ecorse; *for mail*, 802 Ferdinand Ave.
CLIFFORD, Ernest L. ('14), Detroit Dist. Sales Mgr., Babcock & Wilcox Co., 1124 Ford Bldg.
COCKBURN, Leslie S. ('28), Asst. Wks. Engr., Fisher Body Corp., Gen. Motors Bldg.
CONLEY, John W. (J'34), Jr. M. E., Steam Power Plant, Detroit Edison Co., 2000—2nd Ave.; *for mail*, 9333 E. Jefferson.
COOK, Wm. D. ('21; '28; '35), Mgr., Opera. Retail Div., Philgas Dept. Phillips Petroleum Co., 7-101 Gen. Motors Bldg.
COOLEY, M. E. ('84; H'28), Vice-President, '01-'03; President, '19; State Engr. for Mich., Fed. Emergency Admin. Pub. Wks., 1010 Fisher Bldg., Detroit; *for mail*, 249 W. Engrg. Bldg., Ann Arbor.
COON, Thurlow E. (08; '14), Pres., Coon-DeVisser Co., Inc., 2051 W. Lafayette Blvd.
COPE, Edge Taylor ('25; '31), Engr., Detroit Edison Co.; *for mail*, 12850 Lauder Blvd.
COREY, D. H. ('30; '34; '35), Welding Engr., Detroit Edison Co., 2000—2nd Ave.
COX, S. F. ('29), Ch. Engr., Diamond Power Specialty Corp., Box 288.
CROCKER, Sabin ('21; '25), *Junior Award*, '23; Engr., Engrg. Div., Detroit Edison Co., 2000—2nd Ave.; *for mail*, 1037 Yorkshire Ave., Grosse Pointe Park.
CRONIN, Paul L. (J'34), Clerk, Devel. & Engrg. Div., Fisher Body Corp., 3—116 General Motors Bldg.; *for mail*, 11892 Ohio Ave.
CUNNINGHAM, John F., Jr. (J'35), Sales Engr., Lincoln Elec. Co., 2457 Woodward Ave.
CUNNINGHAM, Robt. O. ('21; '35), V. P., Gen. Mgr., Kemmex Products Corp., Penobscot Bldg.; *for mail*, 17206 Pennington Dr.
DARLING, Erwin E. ('29; '35), Plant Engr., Dodge Bros. Corp., 7900 Jos. Campau Ave., Hamtranck, Detroit; *for mail*, 1039 Stanley St., Birmingham.
DEAN, Hugh ('29), Mgr., Forge Div., Chevrolet Motor Co.; *for mail*, Detroit Athletic Club.
DE CENZO, Elbert P. (J'35), Engr., Domestic Airconditioning Co., 171 Victor Ave.; *for mail*, 16261 Monica Ave.
DEVISSER, John H. ('14; '18), V. P., Treas., Coon-DeVisser Co., 2051 W. Lafayette Blvd.
DONOHOE, Chas. F. (J'30), Combustion Engr., Detroit Edison Co., 2000—2nd Ave., Detroit; *for mail*, 7602 Freda, Dearborn.
DOW, Alex ('95; F'36; H'36), Vice-President, '06-'08; President, '28; Pres., Detroit Edison Co., 2000—2nd Ave.
DOW, G. L. ('34), Great Lakes Steel Co., Ecorse, Detroit; *for mail*, Box 37, Ann Arbor.
DRAKE, Chas. M. ('28; '35), Engr., Detroit Edison Co., 2000—2nd Ave., Detroit; *for mail*, 716 Pilgrim Ave., Birmingham.
DRYSDALE, Walter D. ('20), Asst. Engr., Power Plants, Detroit Edison Co., 2000—2nd Ave.
DU COMB, Wm. C. ('13), Pres., W. C. DuComb Co., Inc., 6335 Palmer Ave. E.
DUNAGAN, Shirley V. ('28; '35; '35), Engr., Automatic Heat Div., Kelvinator Corp., 14250 Plymouth Rd.; *for mail*, 9277 Pinehurst Ave.
DWYER, Emmet ('07; '21), Gen. Mgr., Wolverine Porcelain Enameling Co., 3350 Scotten Ave.
DYSARZ, Chas. E. (J'32), 1838 E. Grand Blvd.
EDWARDS, Jos. B. ('21), Dir. Mfg., White Star Ohio Div., Socony-Vacuum Oil Co., Inc., 903 W. Grand Blvd.
EINFELDT, Chas. L. ('29; '35), Piping Design Engr., Detroit Edison Co., 2000—2nd Ave.; *for mail*, 5347 Allendale Ave.
EKSERGIAN, C. L. ('24; '34), Ch. Engr., Budd Wheel Co., 12141 Charlevoix Ave.
ELEY, Robt. V. ('23; '27), Engr., Ford Motor Co., Rouge Plant; *for mail*, 17315 Northlawn Ave.
EMANUELSEN, Johan ('27; '33), Designer, Chevrolet Motor Co.; *for mail*, 1505 Delaware Ave.
ESCH, Rudolf Ernst ('34), 14301 Robson Ave.
ESSELSTYN, Horace H. ('09), Pres., H. H. Esselstyn, Cons. Engr., 1135 Majestic Bldg.
EVANS, Gordon M. ('20), Box 24, Redford Sta.
EVANS, Wellington, F. ('12), Pres., Central Detroit Warehouse Co.; Merchants' Forwarding Terminals Co.; Natl. Transit Corp., 1627 W. Fort St., Detroit; *for mail*, Quarton Rd., R. F. D. 1, Birmingham.
FARRELL, Eugene F. (J'36), M. E., Modern Stamping & Mfg. Co., 226 Mt. Elliot; *for mail*, 8472 Gray Ave.
FEIGE, Wm. (J'35), 221 Edgewood Pl., Ferndale.
FERAR, Robt. (J'34), Power Plant Helper, Mistersky Power Plant, Detroit Pub. Ltg. Comm., 5425 W. Jefferson St.; *for mail*, 3033 Leslie St.
FERRIS, Don M. ('19; '21; '28), 115 Cadillac Sq.
FISHER, Francis P. ('30), Cons. Engr., 735 Randolph St.
FITZGERALD, Jas. F. (J'35), Student Engr., Detroit Edison Co., 2000—2nd Ave.; *for mail*, 250 E. Grand Blvd.
FORD, Henry ('15), *Holley Medallist*, '36; Pres., Ford Motor Co.
FORD, H. Stanley ('21; '35), Asst. to Pres., Sales & Engrg., Bigelow-Liptak Corp., 2842 W. Grand Blvd.
FORSYTHE, Clayton E. ('17; '21), Engrg. Car Prod. Changes, Chrysler Corp., E. Jefferson; *for mail*, 2605 Sturtevant Ave.
FREDERICK, E. A. (J'30), M. E., Serv. Conveyor Co., 7764 Bryden Ave., Detroit; *for mail*, 7505 Kentucky Ave., Dearborn.
FREUND, Clement J. ('23; '25; '33), Dean, College of Engrg., Univ. of Detroit; *for mail*, 17161 Roselawn.
FRITSCHE, Carl B. ('36), Managing Dir., Farm Chemurgic Council, Dearborn Inn, Dearborn; *home address*, 16826 St. Paul Ave., Detroit.
FULLER, Earl Howard ('30), Maint. Engr., Kelsey-Hayes Wheel Corp., 3600 Military Ave., Detroit; *for mail*, 24 Maywood St., Pleasant Ridge, Royal Oak.
GAMMON, Robt. C. ('23), Secy., Asst. Mgr., Morehead Mfg. Co., 4895 Grand River Ave.
GIBSON, H. L. (J'31), Oper., High Temperature Engr., Detroit Edison Co., Delray.
GIFFORD, Chas. R. ('26), 111 Highland Ave., Highland Park.
GILBRETH, Wm. M. (J'36), Engr. Maint., Am. Radiator Co., 8007 Jos. Campau Ave.
GLASIUS, Einar ('28; '35), M. E., Great Lakes Steel Corp., Detroit; *for mail*, 7452 Normile St., Dearborn.
GODDARD, Archibald N. ('13), Pres., Goddard & Goddard Co., 12280 Burt Rd.; *for mail*, 630 Virginia Park.
GOTTSMAN, Victor ('19; '35), 16549 Woodward Ave., Highland Park.
GRAND, Salman (J'33), Gen. Mgr., Nu Motor Sales, 4240 Cass Ave.; *for mail*, 8422 La Salle Blvd.
GRANTIER, L. V. ('15), Heating Engr., Detroit Edison Co., 2000—2nd Ave., Detroit; *for mail*, 153 Hendrie Blvd., Royal Oak.
GRAVES, Walter J. ('17), Indus. Engr., Mich. Mutual Liability Co.; *for mail*, 520 Josephine Ave.
GREEN, Heatley ('19), Pres., Automatic Products Co., 1145 W. Grand Blvd.
GREINER, Frank ('25; '35), Branch Mgr., Landis Tool Co.; *for mail*, 166 Connecticut Ave.
HALPIN, Carl L. ('29; '35), Supt., Charge Factory, Fruehauf Trailer Co., Inc., 10940 Harper St.; *for mail*, 4835—3-Mile Dr.
HANS, Walter R. ('24; '35), Dist. Mgr., Whiting Corp., Rm. 307, Machinery Bldg.
HANSON, Ray F. ('25; '32; '35), M. E., Sales & Serv., Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio; *for mail*, 15084 Lesure Ave., Detroit, Mich.
HARRINGTON, Ferris T. ('30; '35), Sales Engr., Vickers, Inc., 1400 Oakman Blvd.; *for mail*, 16200 Parkside.
HARRISON, Chas. G. ('24), Mich. Agt., Springfield Boiler Co., of Springfield, Ill., Bigelow Co., of New Haven, Conn.; *for mail*, 4512 Cortland Ave., Detroit, Mich.
HAUTAU, Llewellyn A. (J'33), 15385 Petoskey.
HAY, Barclay Wm. (J'27), Power Engr., City of Detroit; *for mail*, 13956 Washburn St.
HEATH, Delos Parker ('23), Ch. Engr., McCord Radiator & Mfg. Co.; *for mail*, 58 Muskoka Rd., Grosse Pointe Farms.
HEFTLER, Victor R. ('14), Pres., Zenith-Detroit Corp., Foot of Hart Ave.
HELMRICH, G. Bernard ('21; '35), M. E., Detroit Edison Co., 2000—2nd Ave., Detroit; *for mail*, 26590 Dundee Rd., Huntington Wood, Royal Oak.
HENDRICKSON, G. A. ('26; '32; '35), Engr., Detroit Edison Co., 2000—2nd Ave., Detroit; *for mail*, 6861 Neckel Ave., Dearborn.
HEYMAN, Saml. N. ('34), M. E., Constr. Engrg. Dept., Fisher Body Corp., Gen. Motors Bldg.; *for mail*, 3224 Sturtevant.
HILL, Maj. Reuben ('08), Cons. Indus. Engr., 400 Owen Bldg.; *for mail*, 2305 Park Ave.
HINDMAN, W. L. ('14; '35), Tool Engr., Chrysler Corp.; *for mail*, 16159 Lilac Ave.
HIRSHFELD, Clarence F. ('05; '19; F'36), Manager, '29-'32; Vice-President, '32-'34; Ch. of Research, Detroit Edison Co., 2000—2nd Ave.
HOFFMAN, Roscoe C. (14; '16; '35), Hoffman Motor Developments Co., 3784 E. Fort St.
HOLMES, Harold W. ('12; '25), Pres., H. W. Holmes Corp., 5057 Woodward Ave.
HONYWILL, Albert. W., Jr. ('11; '16; '23), Treas., Diamond Power Specialty Corp., 10340 Oakland Ave.
HOUGHTON, Ralph Hunt (J'29), Process Engr., Natl., Mch. & Tool Specification, Packard Motor Car Co., 1580 E. Grand Blvd.; *for mail*, 680 Longfellow Ave.
HUGHES, Raymond M. ('34), Asst. Ch. Engr., Great Lakes Steel Corp., Ecorse, Detroit; *for mail*, 711 Meridan Ave., W. Dearborn.

HUNTOON, Chas. H., Jr. (J'33), Sales Engr., Norma-Hoffman Bearings Corp., 3308 Eaton Tower; *for mail*, 210 Highland Ave., Highland Park.
IBSER, Henry P. (J'36), Co-operative Student, Tool., Chrysler Corp., 12200 E. Jefferson; *for mail*, 203 W. Grand Ave., Highland Park.
IMBODEN, Chas. ('27; '35), Export Prod. Engr., Chrysler Corp., Massachusetts, Highland Park; *for mail*, 18637 Cherrylawn.
INGRAM, Wm. T. (J'36), Exper. Engr., Chrysler Corp., Oakland Ave.; *for mail*, 209 Colorado St., Highland Park.
JAMES, John R. ('29), Sr. Engr., Civil & Mech. Design, Detroit Edison Co., 2000—2nd Ave.
JARNAGIN, Jas. F. (J'24), Budget Dept., Dodge Bros. Corp., 7900 Jos. Campau Ave., Hamtramck; *for mail*, 14264 Promenade.
JEFFORDS, Thomas Wortman ('29; '35), Power Plant Supt., Public Ltg. Comm., City of Detroit, 5425 W. Jefferson.
JILLSON, Oscar Allen (J'36), Stores Dept., Hudson Motor Car Co., E. Jefferson; *for mail*, Y. M. C. A., E. Jefferson.
JOHNSON, B. J. (J'35), Asst. Buyer, M. E., Ford Motor Co., Rouge Plant, 3674 Schaefer Rd., Dearborn; *for mail*, 14597 Mark Twain, Detroit.
JOHNSON, Wm. H. ('20; '35), Asst. to Indus. Engr., Detroit City Gas Co., 415 Clifford St.; *for mail*, 13340 Coyle Ave.
KARL, Wm. C. (J'32), Engr., Research Dept., Continental Motors Corp., 12801 E. Jefferson; *for mail*, 979 Lakepointe Ave., Grosse Pointe Park.
KEARNEY, Thos. J. (J'34), Plant Engr., Charge Maint., Detroit Rex Products Co.; for mail, Apt. 102, 120 Seward St.
KELLER, K. T. (A'16), V. P., Gen. Mgr., Dodge Bros. Corp., 7900 Jos. Campau Ave., Hamtramck.
KENNAUGH, John P. (J'32), Instr., Univ. of Detroit, 630 E. Jefferson.
KETTERING, Chas. F. ('15), Gen. Dir., Research Labs., Gen. Motors Corp., Gen. Motors Bldg..
KEYS, Walter C. ('36), 749 Calvert Ave.
KINNARD, Jas. A. ('29), 5-251 Gen. Motors Bldg.
KINNEY, Watson F. (J'29), Jr. Engr., Prod. Dept., Detroit Edison Co., 2000—2nd Ave.
KLESSIG, Ernst F. (J'30), Apt. 304, 361 Merton Rd.
KNAUER, Ebert ('19), Research Engr., Burroughs Adding Mch. Co.; *for mail*, 4269 Fullerton Ave.
KNIBBE, Klaas (J'26), Research Engr., Aircraft, Continental Motors Corp., E. Jefferson; *for mail*, 1363 Manistique St.
KNOBLOCK, A. F. ('14), Exec. V. P., Gen. Mgr., Bundy Tubing Co.; *for mail*, 661 Edison Ave.
KNOCKE, Louis T. ('20; '22), Engr., Engrg. Dept., Chrysler Corp., Highland Park; *for mail*, 20050 Renfrew Rd.
KOEFOED, Thorkild (J'31), M. E., Gen. Motors Co., General Motors Bldg.; *for mail*, 1421 Delaware.
KRAMER, Delbert F. (J'36), 17524 Parkside Ave.
KREBS, Henry J. ('32), Engrg. Dept., Packard Motor Car Co.; *for mail*, 3450 Chicago Blvd.
KREIDLER, D. W. ('17), Engrg. Staff, Hudson Motor Car Co.; *for mail*, 633 Lincoln Rd., Grosse Pointe.
LACCHIA, Jos. F. (J'26), Sales Engr., E. W. Bliss Co., 1109 Fisher Bldg., Detroit; *for mail*, 1612 W. Shiawassee, Lansing.
LAUER, Robt. John (J'31), Designer, Gen. Motors Corps., General Motors Bldg; *for mail*, 16844 Mendota.
LEATHERMAN, Lloyd R. ('31; '35), Bernitz Furnace Appliance Co., 2140 Book Bldg.
LENTZ, Lawrence W. (J'36), Student Engr., Engrg. Div., Chrysler Corp., Oakland Ave., Highland Park, Detroit; *for mail*, Route 1, Box 65, Algonac.
LINDSLEY, Chas. W. (J'35), Student Engr., Detroit Branch, Natl. Biscuit Co., 899 W. Baltimore St.; *for mail*, 6388 Trumbull Ave.
LINSENMEYER, Francis J. ('28; '30), Head M. E. Dept., Univ. of Detroit, McNichols at Livernois.
LITTLE, Edwin R. ('16; '21), Pres., E. R. Little Co., Inc., 181 Ford Bldg.
LITTY, Francis E. (J'36), Student (Co-operative), Cadillac LaSalle Motor Co., Clark St., Detroit, Mich.; *for mail*, 511 Beattie St., Sterling, Colo.
LLOYD, C. G. ('25; '35), Designer, Vickers, Inc., 1400 Oakman Blvd.; *for mail*, 12000 Ward Ave.
LONEY, Neil McI. ('21), Fisher Body Corp., Gen. Motors Bldg.
LOVEJOY, E. P. (A'35), Gen. Mgr., Detroit Elec. Furnace Co., 825 W. Elizabeth St.
LOVELL, Thos. S. ('36), 551 Kitchener Ave.
LYKE, Henry W. ('15), Engr., Peter Smith Heater Co., 6209 Hamilton Ave.
MABEE, Ernest W. ('26; '35), Maint. Engr., Dodge Bros. Corp., 7900 Jos. Campau Ave., Hamtramck; *for mail*, 4065 Field Ave.
MABLEY, T. Hollister (J'36), Engr., Charge Design, Mech. Heat & Cold, Inc., 7704 Woodward Ave.
MacGILLIS, Dan J. (J'32), Exper. Engr., Long Mfg. Co., Dequindre St.; *for mail*, 19633 Russell St.
MAIER, Dwight C. ('19; '35), 1040 E. Grand Blvd.
MALLY, Geo. Gregory (J'34), Draftsman, Bundy Tubing Co., 10951 Hern Ave.; *for mail*, 229 E. Bennett St., Ferndale.
MALONEY, Steve C. (J'35), Eng. Dept., Packard Motor Co.; *for mail*, 3440 Santa Maria.
MARCERO, Aloysius ('23), Plant Engr., Conners Creek Power House, Detroit Edison Co.
MARTI, Chas. ('25), Adding Mch. Designer, Burroughs Adding Mch. Co., Second Blvd., Detroit; *for mail*, 9913 Berwick Ave., Plymouth.
MAYO, Wm. B. ('00), 1457 Seminole Ave.
MAYROSE, Herman E. ('29), Prof. Engrg. Mechanics, Univ. of Detroit, McNichols at Livernois.
McCABE, John C. ('15), Ch. Boiler Inspr. of State of Mich.; *for mail*, 5450—16th St.
McCUTCHAN, Arthur (J'31), Engr., Detroit Edison Co., 2000—2nd Ave.; *for mail*, 14263 Hubbell Ave.
McDONALD, James J. (J'35), 3974 Commonwealth.
McGREGOR, Howard L. ('21; '35), Pres., Natl. Twist Drill & Tool Co., 6522 Brush St.
McGUIRE, Donald E. ('34), Ch. Draftsman, Great Lakes Steel Corp., Ecorse, Detroit; *for mail*, 301 Emmons Blvd., Wyandotte.
McINTIRE, J. F. ('22), V. P., Engrg. & Mfg., U. S. Radiator Corp., 1056—1st Natl. Bank Bldg.
McKEOWN, Gregory M. (J'35), Test Engr., Vickers, Inc., 1400 Oakman Blvd.; *for mail*, 57 Elmhurst, Highland Park.
McKNIGHT, Wm. H., Jr. (J'34), Asst. Plant Engr., Bowen Products Corp., 2760 W. Warren; *for mail*, 16148 Indiana.
MERRILL, S. Clifford ('18; '23; '30), Dist. Mgr. of Sales, Timken Roller Bearing Co., 1711 Fisher Bldg.
MERRITT, L. Ford ('33), V. P., Charge Engrg. & Sales, Mich. Leather Packing Co., 6301 E. Lafayette Ave.
MILLER, John G. (J'34), Engr., Research Lab., Detroit Edison Co., 2000—2nd Ave.; *for mail*, Apt. 312, 1313 Seward St.
MILLER, Norman E. ('35), Research Engr., Vickers, Inc., 1400 Oakman Blvd.
MILLS, Halstead H. (A'22), Ch. Safety Engr., Dept. of Bldgs. & Safety Engrg., City of Detroit, 555 Clinton St.
MITCHELL, Norman T. ('27; '35), Engr., Detroit Sulphite Pulp & Paper Co., W. Jefferson; *for mail*, 9205 Birwood St.
MOTT, Chas. S. ('98; '09), V. P., Gen. Motors Corp., Gen. Motors Bldg.
MOUNT, Ralph H. ('17), Asst. to Pres., Engr., Maint. & Plant Layout, Essex Wire Corp., 14310 Woodward St., Detroit; *for mail*, 26034 Dundee Rd., Huntington Woods, Royal Oak.
MURCH, Stanley (J'25), Hartford Steam Boiler Inspc. & Ins. Co., 2401 1st Natl. Bank Bldg.
MUTIMER, Adelbert G. (J'34), Rm. 627, Adams Ave. Branch of Y. M. C. A.
NAIMAN, Julius M. ('22; '26; '35), Cons. Engr., 503 Water Board Bldg.
NEIL, Edmund B. ('15; '20; '28), M. E., N. W. Ayer & Son Inc., 4200 Penobscot Bldg.
NELSON, Harry F. (J'34), Apprentice Toolmaker, Ex-Cell-O Aircraft & Tool Corp., 1200 Oakman Blvd.; *for mail*, 317 Pilgrim Ave., Highland Park.
NICHOLS, Wm. Westervelt ('26), M. E., D. P. Brown Co., 516 Howard St.
NICKLIN, Ernest W. ('00; '30), Pres., E. W. Nicklin Co., 413 Stephenson Bldg.
NICOLETTI, Geo. W. (J'34), 16203 Greenlawn.
NOACK, Hans W. L. (J'27), Hyd. Brake Co., 84 W. Hancock St.; *for mail*, 222 S. Algonquin St.
NUGENT, E. L. ('36), Asst. Engr., Detroit Edison Co., 2000—2nd Ave.
OAKLEY, Warren B., Jr. (J'35), 17301 Kentucky Ave.
OFFER, Louis A. ('21), Cons. Engr., 300 Westminster Ave.
OLESEN, Tage C. (J'27), Project Engr., Vickers, Inc., 1400 Oakman Blvd.; *for mail*, 13045 Wilshire.
OLIVER, Frank J. Jr. ('22; '28; '35), Detroit Editor, Iron Age, 7310 Woodward Ave.
OLLEY, Maurice ('27), 18205 Parkside Ave.
OLTEAN, Geo. (J'36), 13031 Orleans St.
ORAZIO, Fred D. (J'34), 5551 Springfield Ave.
OTTE, Arthur F. (J'34), Instr., Mch. Shop, Detroit Pub. Schs., 4333—12th St.
OUTZEN, Andrew N. ('22; '28), Supt., Sta. "J" & River Rouge Plants, Detroit City Gas Co., 415 Clifford St.
OXFORD, Carl J. ('21; '35), Factory Supt., Ch. Engr., Natl. Twist Drill & Tool Co., 6522 Brush St.
PALMER, Wm. C. ('22; '35), Serv. Mgr., Westinghouse Elec. & Mfg. Co., 5757 Trumbull Ave..
PANTON, Wm. R. ('30), Ch. Engr., Charge Design, Maint., Dunbar & Sullivan Dredging Co., 2312 Buhl Bldg.
PARKER, Jas. W. ('13; '25), Manager, '35-'38; V. P., Ch. Engr., Detroit Edison Co., 2000—2nd Ave.
PASINI, A. C. ('30; '34), Tech. Engr., Connors Creek Power Plant, Detroit Edison Co.; *for mail*, 4390 Bedford Rd.
PATT, I. Fred (J'35), 3751 Clements Ave.
PEPPLER, Wayne C. (J'35), 2965 Calvert.
PERKINS, Donald L. ('18; '23; '28), Head, Mech. Engrg. Dept., College of Engrg., Wayne Univ., Cass at Warren St.; *for mail*, 16511 Ward Ave.
PERKINS, Percy M. ('30; '35), Asst. M. E., Dept. Pub. Wks., City Engr's. Office, City of Detroit, 601 Water Board Bldg.; *for mail*, 8847 Mendota Ave.
PHELPS, Kenneth G. ('30; '35), Indus. Engr., Chevrolet Motor Co., W. Grand Blvd.; *for mail*, 5275 Kensington Ave.
PIERCE, Earl R. (J'29), M. E., Research Div., Gen. Motors Corp; *for mail*, 14441 Greenview Blvd.
PLANCHE, E. ('17), Cons. Engr., 2834 E. Grand Blvd.
POLK, G. C. ('33), Ch. Engr., Am. Blower Corp., 6000 Russell St.
POPYK, Wm. W. (J'35), 6942 Parkwood Ave.
POSTEL, Kenneth I. (J'36), Draftsman, Vickers, Inc., 1400 Oakman Blvd.; *for mail*, 15950 Linwood.
POTTS, Virgil M. ('31; '35), Supt. Press Rm., Detroit Times; *for mail*, 518 Dickerson Ave.
PREBLE, Norman H. ('29), Ch. Engr., Jervise B. Webb Co., 9001 Alpine Ave.
PRICE, Floyd U. ('21; '35), Sales Engr., Jas. E. Degan Co., 2130 E. Franklin St.; *for mail*, 18516 Prairie Ave.
RANDALL, John F. (J'36), Research Engr., Hedges-Walsh-Weidner Co., 1032 W. Main St., Chattanooga, Tenn.; *home address*, 14215 Mark Twain Ave., Detroit, Mich.
RAYMOND, Ernest P. ('23; '35), Asst. Ch. Engr., Pure Pak Div., Ex-Cell-O Aircraft & Tool Corp., 1200 Oakman Blvd.; *for mail*, 8883 Pinehurst Ave.
RECH, Herbert F. ('27), Dir., Power Sec., Gen. Motors Corp., Gen. Motors Bldg.; *for mail*, 1246 Edison Ave.
REED, Geo. S. (J'34), Boiler Oper., Univ. of Detroit, Power House, McNichols at Livernois; *for mail*, 15410 Ilene St.
REED, Wm. Anthony ('28), Gen. Supt., Solvay Process Co., 7501 W. Jefferson; *for mail*, 15775 Rosemont Rd.
RIDDELL, Jas. (J'36), Draftsman, Great Lakes Steel Corp., Ecorse, Detroit; *for mail*, 5482 Steadman St., Dearborn.
RIORDAN, John M. ('21), Pres., Salesman, Riordan Mchy. Co., 213 Curtis Bldg.; *for mail*, 2233 Tuxedo Ave.
ROBERTS, Edwin D. (J'31), Jr. Engr., White Star Refining Co.; *for mail*, 4337 Seebaldt Ave.
ROBINSON, Herbert R. (J'36), 4850 Bedford Rd.
RODEMEYER, H. ('19; '27), Sales Dept., Barnes-Gibson-Raymond, Inc., 6400 Miller Ave.; *for mail*, 2936 Glendale Ave.
ROOT, Geo. E. (J'34), 15915 Dexter Blvd.
RUDD, Wm. C. ('23), Asst. Engr., Power, Dept. of Water Supply, 735 Randolph St.
SANTTI, Karl E. (J'35), Toolmaker, Dodge Bros. Corp., 7900 Jos. Campau Ave.; Hamtramck; *for mail*, 1546 Grand Ave.
SAUER, Robt. L. ('31), Dist. Sales Mgr., Riley Stoker Corp., Foot of Walker St.
SAULSON, S. ('27), M. E., Charge Design, Albert Kahn, Inc., 345 New Center Bldg.; *for mail*, 12524 Broadstreet Blvd.
SCHECHTER, John P. (J'35), Engr., House Htg. Dept., Detroit City Gas Co., 415 Clifford St.; *for mail*, 1812 Burns Ave.
SCHMALHURST, G. H. (J'32), Apprentice Engr., Steel & Tubes, Inc., 224 E. 131st St., Cleveland, Ohio; *for mail*, 405 Savannah, Detroit, Mich.
SCHRENK, Louis J. ('28), Gen. Supt., Pub. Lighting Comm., 174 Atwater St.
SCHUBERT, Frank R. ('16; '26), Asst. to Pres., Bearings Co. of Am., Lancaster, Pa.; *for mail*, 15041 Warwick Rd., Detroit, Mich.
SCHWENN, Carl A. (J'36), 285 Florence Ave., Highland Park.
SEGALL, Karl B. ('29), Pres., Karl B. Segall Engrg. Co., 19519 Shrewsbury Rd.
SELVING, H. T. ('30), Fisher Body Corp., Gen. Motors Bldg., *for mail*, 8570 Pinehurst Ave.
SELVEY, Arthur M. (J'30), Engr., Mach. Study Sec., Eng. Div., Detroit Edison Co., 2000—2nd Ave.
SHANNON, Don H. ('27), Mech. Designing Engr., Detroit Edison Co., 2000—2nd Ave.
SHUTKO, Frank W. (J'36), Jr. Engr., Detroit Edison Co., 2000—2nd Ave., Detroit; *for mail*, Box 87, Trenton.
SINTZ, Claude ('17), 1940 Stanley Ave.
SKINNER, Sherrod E. ('21; '31), Gen. Mgr., Ternstedt Mfg. Div., Gen. Motors Corp., 6307 W. Fort St.

SLOMER, Wm. F. ('09), Gen. Sales Mgr., Fellows Gear Shaper Co., 1149 Book Bldg.; *for mail*, 19690 Chesterfield Rd.
SMALL, Louis (J'34), V. P., Charge Mfg., Abrasive Dressing Tool Co., 1550 Broadway.
SMITH, Morgan B. ('21), Pres., Morgan B. Smith Co., 4-250 Gen. Motors Bldg.; *for mail*, 9570 Prairie Ave.
SMITH, Warren H. ('28; '35; '35), 52 Piquette Ave.
SMITH, Young C. ('35), Prop., Young C. Smith & Co.; *for mail*, 1401 Woodland Ave.
SPURGEON Jos. H. ('27), Rep., Spurgeon Co., 5-203 Gen. Motors Bldg.
STARKWEATHER, John D. (J'31), Student Engr., Detroit Edison Co.; *for mail*, 17130 St. Paul, Grosse Pointe Village.
STELLWAGEN, Robt. H. ('24; '30; '35), Assoc. M. E., Charge Pumping Stas., City of Detroit, 414 City Hall; *for mail*, 4324 Maryland Ave.
STERLING, C. H. ('16; '19; '23), Chrysler Corp.; *for mail*, 103 McLean Ave.
STERN, Bernhard ('28: '35), Exper. Engr., Chrysler Corp., Highland Park; *for mail*, 18455 Parkside Ave.
STEWART, B. C. ('30), Asst. Engr., Smith Hinchman & Grylls, 800 Marquette Bldg., Detroit; *for mail*, 647 Park Ave., Birmingham.
SUCZEK, Robt. ('19), Research Engr., Hudson Motor Car Co., Jefferson Ave.; *for mail*, 591 Fisher Rd., Grosse Pointe.
SWEET, Charles E. ('07), Treas., Superior Mch. & Engrg. Co., 1930 Ferry Park; *for mail*, 691 Taylor Ave.
TENKONOHY, Franklin V. ('16; '35), 5019 Ridgewood Ave.
THOMAS, Ross W. ('21; '33), Mgr., Philgas Dept., Phillips Petroleum Co., 7-101 Gen. Motors Bldg.
THOMAS, Willis P. ('29), Pres., Diamond Power Specialty Corp., 10340 Oakland Ave.
THOMPSON, Earl A. ('25), Asst. Ch. Engr., Cadillac Motor Car Co., Detroit; *for mail*, 587 Henley Dr., Birmingham.
THOMPSON, Paul W. ('15; '25), Ch. Engr., Power Plants, Detroit Edison Co., 2000—2nd Ave.
THOMPSON, Wm. Tulloch (J'32), Jr. Engr., Motor Design, Chrysler Corp.; *for mail*, 165 Colorado Ave., Highland Park.
THORSON, Allen W. (J'29), Jr. Engr., Prod. Dept., Rm. 619, Detroit Edison Co., 2000—2nd Ave.
TOBEY, Thos. J. ('18; '25), Engr., Everhot Heater Co., 5241 Wesson Ave.; *for mail*, 5282 Oregon Ave.
TOOTHACKER, W. Sanford, Jr. (J'30), Draftsman Engrg. Research, Chrysler Corp., Oakland Ave.. Highland Park; *for mail*, 52 Ferris, Highland Park.
TRACY, Lawrence E. (J'33), 630 Merrick Ave.
TRUE, George R. (J'34), 1944 Atkinson.
TULUS, Eugene A. ('36), Devel. Engr., Kelvinator Corp., Plymouth Rd.; *for mail*, 13728 Wadsworth Ave.
TWYMAN, L. R. (J'30), Sales Application Engr., Vickers, Inc., 7752 DuBois; *for mail*, 731 Covington Rd.
UDALE, Stanley M. ('30), Engr., Pat. Atty., Holley Carburetor Co., Vancouver Ave. & P. M. Ry.
UEBE, Ernst K. ('22; '29), Charge New Business Dept., Diamond Power Specialty Corp., P. O. Box 851.
URSCHALITZ, Paul E. (J'33), Transportation Engr., Gen. Motors Truck Co., 3925 Vermont Ave.
Van AKEN, Col. Lionel Dederick ('18), Dist. Mgr., Engrg. & Sales, Dictograph Products Co., Inc., 2111 Woodward Ave.; *for mail*, 5100 Yorkshire Rd.
Van DUSEN, C. T. (J'20), Buyer, Mech. Equip., Detroit Edison Co., 2000—2nd Ave.
Van HENGEL, Gerrit H. ('22; '27), M. E., Power Plants, Detroit Edison Co., 2000—2nd Ave., Detroit; *for mail*, 19 Elm Park Blvd., Pleasant Ridge, Royal Oak.
Van KAMMEN, Isaac J. ('19; '35), Dist. Mgr., Wickes Boiler Co., 2357 Union Trust Bldg., Detroit; *for mail*, 1576 Fisk Rd., Grand Rapids.
VanTINE, Chas. H. ('20), Sales Engr., Giffels & Vallet, Inc., 1000 Marquette Bldg.; *for mail*, 995 Nottingham Rd., Grosse Pointe Park.
VINCENT, Edw. T. ('29), Ch. Engr., Diesel Div., Continental Motors Corp., E. Jefferson; *for mail*, 2271 Cadillac Blvd.
VINCENT, Col. Jesse G. ('08; '10), V. P. Engrg., Packard Motor Car Co., 1580 E. Grand Blvd.
Von ROTZ, Robt. (J'20), 17400—3rd Ave.
WAGNER, Harvey A. (J'28), Engr., Engrg. Div., Detroit Edison Co., 2000—2nd Ave., Detroit; *for mail*, 7918 Theisen Ave., Dearborn.
WALKER, Jas. H. ('29), Engr. Asst. to Gen. Mgr., Detroit Edison Co., 2000—2nd Ave.
WALTON, Hiram L. ('36), Ch. Engr., Smith, Hinchman & Grylls, 800 Marquette Bldg.
WAMBOLD, Frank H. (J'29), Die Engrg., Dodge Bros. Corp., 7900 Jos. Campau Ave., Hamtramck; *for mail*, 4009 Richton St.
WARE, Marsden (J'22), 4352 Buena Vista.
WEBB, Baxter H. (J'36), Gen. Office, Sales Engrg. Htg. Systems, Crane Co., 150 Randolph St.; *for mail*, 79 E. Philadelphia St.
WEBB, Jervis B. ('27), Pres., Gen. Mgr., Jervis B. Webb Co., 9001 Alpine Ave.
WELLS, J. Milton (J'26), Motch & Merryweather Mchy. Co., 2842 W. Grand Blvd.
WERT, Edwin A. ('31), Engr., Detroit Edison Co., 2000—2nd Ave.; *for mail*, 16881 Shaftsbury.
WEST, Frank, R. ('21; '25; '35), Cons. Engr., Kelvinator Corp., Plymouth Rd.; *for mail*, 10015 Grandville Ave.
WETZEL, John J. (J'36), Specialized Inspc., Dodge Bros. Corp., 7900 Jos. Campau Ave., Hamtramck; *for mail*, 12306 Glenfield Ave.
WHITT, Sidney A. (J'33), Air Conditioning & Refrig. Engr., Kelvinator Corp., 14250 Plymouth Rd.
WILLI, Albert B. ('36), Ch. Engr., Fed.-Mogul Corp., 11031 Shoemaker; *for mail*, 1342 Nottingham Rd.
WILLIAMS, Paul ('17; '25), Skinner Purifiers. Inc., 2231 Dalzelle St.
WOOD, E. E. ('00), Life Member; Partner, Charge Sales, Haberkorn & Wood, 2832 E. Grand Blvd.
WOOLFENDEN, Henry L. ('18), Mfrs. Rep., 604 Fisher Bldg.; *for mail*, 1963 Leslie St.
WOOLSON, Harry T. ('07), Exec. Engr., Chrysler Corp., 12800 Oakland Ave.
WRIGLEY, Clifford C. (J'35), Research Engr., Ethyl Gasoline Corp., 723 E. Milwaukee Ave.
YODER, Howard D. ('20), Engr. Injector Div., Penberthy Injector Co., 1242 Holden Ave.; *for mail*, 69 Massachusetts, Highland Park.
ZACEK, Oscar S. (J'35), 12591 Hampshire.
ZACK, Eugene S. ('23; '35), Analyst, Gen. Motors Corp., Gen. Motors Bldg.; *for mail*, 1510 Virginia Park.
ZAHN, O. F., Jr. (J'32), Engr., Testing, Ex-Cell-O Aircraft & Tool Corp., 1200 Oakman Blvd.
ZEDER, Fred M. ('20), Vice-Chmn. of Bd., Charge Engrg., Chrysler Corp.
ZIMMERLI, Franz P. ('27), Ch. Engr., Barnes-Gibson-Raymond, Inc., 6400 Miller Ave.

DOWAGIAC, St. Joseph Valley Section

SEDLACK, Edmund C. (J'33), Jr. Engr., Test Dept., No. Ind. Pub. Serv. Co., Hohman St., Hammond, Ind.; *for mail*, 506 Orchard St., Dowagiac, Mich.

EAST LANSING, Detroit Section

ANDERSON, Edw. ('27), Instr. M. E., Mich. State College of Agri. & Applied Sci.
COLE, Ralph A. (J'20), Asst. Wks. Mgr., Motor Wheel Corp., 716 E. Saginaw St., Lansing; *for mail*, 505 Ardson Rd., E. Lansing.
DIRKS, Henry B. ('07; '16; '30), Dean of Engrg. Mich. State College of Agri. & Applied Sci.; *for mail*, 637 Grove St.
FIELD, Lawrence N. ('17; '35), Prof. Mch. Design. Mich. State College; *for mail*, 519 Forest Ave.
REULING, Walter E. ('29), Asst. Prof. M. E.. Mich. State College of Agri. & Applied Sci.; *for mail*, 130 Fern St.
RIX, C. N. ('34; '35), 901 Abbott Rd.
WRIGHT, Ralph C. (J'29), Test. Engr., Bd. of Water & Elec. Light Comm.; *for mail*, 331 Evergreen.

FILER CITY, Peninsula Section

HULTAN, K. A. ('26; '35), Plant Engr., Filer Fibre Co., Filer City; *for mail*, P. O. Box 241, Manistee.

FLAT ROCK, Detroit Section

CHAPIN, Edw. A. (J'34).

FLINT, Detroit Section

DEMOREST, Geo. E. (J'30), Eff. Engr., A. C. Spark Plug Co.; *for mail*, 628 E. 2nd St.
ELWELL, Frank D. ('19; '25), Wks. Engr., Buick Motor Co.; *for mail*, 2250 Nolan Dr.
FALLON, John H. ('19; '26; '35), M. M. Office. A. C. Spark Plug Co., Harriet St. & Industrial Ave.; *for mail*, 150 E. Flint Park Blvd.
FREY, Alfred T. ('27; '33; '35), Incentive Wage Engr., Charge Finishers Div., E. I. du Pont de Nemours & Co.; *for mail*, 1408 Root St.
McELHOSE, Lester G. ('29; '31; '35), Test Engr., A. C. Spark Plug Co.; *for mail*, 2811 Mason St.
McMACKEN, Donald Clements (J'35), 421 W. Paterson St.
SPAHR, Robt. H. ('33), Dir. of Instruction & Curricula, Gen. Motors Inst.
STOUGHTON, Geo. H. (J'34), Instr., Automotive & Diesel Design, Gen. Motors Inst.
TUTT, Chas. L., Jr. (J'33), Student Engr., Buick Motor Co., Hamilton Ave.; *for mail*, 2919 Detroit St.

GRAND RAPIDS, Peninsula Section

BENEDICT, LeRoy L. ('22), Div. Supt., Consumers Power Co., 129-131 Pearl St.
CORNELIUS, L. A. ('31), Pres., Wolverine Brass Wks.
DORMAN, Warren W. (J'33), Prod. Engr., Keeler Brass Co.; *for mail*, 417 Airview St.
HETLER, Bruce P. (J'34), Ch. Engr., Blackmer Rotary Pump Co., 1809 Century Ave., S. W.; *for mail*, 401 Prospect Ave., S. E.
KLISE, Robt. E. (J'33), *Charles T. Main Award*. '31, Independent Devel., Design, 2909 Beechwood Dr., S. E., E. Grand Rapids.
KUENZEL, Carl J. (J'36), 816 Bridge St.
KURKJIAN, Armen S. ('22; '35), Dir. Sales Mgr., Oliver Mchy. Co.; *for mail*, 552 Gladstone Ave.
NORRIS, Chas. B. ('26), Cons. Engr., Am. Boxboard Co.; *for mail*, 245 Paris Ave.
RICHARDSON, Bayard E. ('29), Engr., Charge Design & Prod., Gunn Furniture Co., Ann St.; *for mail*, 439 Fuller Ave., S. E.
ROGERS, Lewis C. ('12), 824 Beals Rd.
SLAUGHTER, Chas. H. ('25; '35), Gen. Mgr., Kent Mch. Co.; *for mail*, 257 Henry Ave.
Van DONGEN, D. W. ('27), Ch. Engr., Blackmer Rotary Pump Co., 1809 Century Ave., S. W.
Van STEENWYK, Henry W. (J'31), Engr., Design. Haskelite Mfg. Corp.; *for mail*, 209 Charles Ave., S. E.
WALKER, A. Marriott (J'36), 311 E. Fulton St.
WARING, Geo. H. ('23), Cons. Engr., 1611 Pontiac Rd., S. E.
WELLS, Robt. Lee (J'35), Keeler Brass Co.; *for mail*, 1310 Sigsbee St., S. E.

GREENVILLE, Peninsula Section

SAUNDERS, Fred S. ('18; '26), Prod. & Plant Engr., Ranney Refrigerator Co.; *for mail*, 314 S. Irving St.

GROSSE ILE, Detroit Section

KARMAZIN, John ('14; '35), Cons. Engr., Frigidaire Div., Gen. Motors Corp., Huntington. Ind., Pres., Karmazin Engr. Co., Grosse Ile; *for mail*, Grosse Ile, Mich.
LANE, Henry M. ('00), Cons. Engr., Gray Gables.

HOLLAND, Peninsula Section

LOHMANN, Conrad G. ('27; '30; '35). Engr., Charge Tool Design, Hart & Cooley Mfg. Co.; *for mail*, 56 E. 21st St.

HOUGHTON

RISTEEN, Horace W. ('25; '35), Asso. Prof. M. E., Mich. College of Min. & Tech.; *for mail*, 64 E. 5th St.
SEEBER, R. R. ('36), Prof., College of Min. & Tech.
YOUNG, Prof. Almon Paul ('34), Assoc. Prof. M. E., Mich. College of Min. & Tech.

HUBBELL

BURGAN, A. L. ('97; '99; '03), Mill Supt., Calumet & Hecla Consltd. Copper Co.

ISHPEMING

McCLURE, Duncan D. (J'31), Engr., Mich. Gas & Elec. Co.; *for mail*, 657 Jasper St.
McCLURE, O. D. ('07), Ch. M. E., Cleveland Cliffs Iron Co.

JACKSON, Detroit Section

BOYCE, Frank G. ('21), Mgr., Elec. Prod. & Transmission Dept., Consumers Power Co., W. Main St.
DANIELS, Geo. C. ('14; '18), M. E., Commonwealth So. Corp., Consumers Power Bldg.
FROST, E. J. ('08), Retired; 904 W. Michigan Ave.
HUNT, Horace S. ('19), Pres., Fargo Engrg. Co., 120 W. Michigan Ave.
MACKENZIE, Jos. Wesley ('22; '26), Mech. Supvr., Opera. Dept., Consumers Power Co., 212 W. Michigan Ave.
MOFFETT, Henry C. ('21), Engrg. Rep., Pittsburgh Piping & Equip. Co., 43d St. & A. V. R. R., Pittsburgh, Pa.; *for mail*, 218 N. Higby St., Jackson, Mich.
PARKINSON, Russell W. (J'26), Asst. M. E., Commonwealth & So. Corp., Consumers Power Bldg.
RIETHMILLER, Earl R. (J'28), Ch. Engr., Cardon Phonocraft Corp., 115 S. Horton Ave.; *for mail*, 786 Oakridge Dr.
Von VOIGHTLANDER, O. ('27), 1204—4th St.

KALAMAZOO, Peninsula Section

DeHAMER, Janus R. (J'35), Designer & Draftsman, Shakespeare Co., N. Pitcher St.; *for mail*, 2017 S. Burdick St.
DOWNS, Sewell H. ('23; '34), Ch. Engr., Charge Engrg. & Research, Clarage Fan Co., 619 Porter St.; *for mail*, 211 Creston Ave.
GIBBS, Chas. R. ('21; '25), Supt. Maint., Kalamazoo Vegetable Parchment Co., Kalamazoo; *for mail*, 295 Glendale Blvd., Parchment.
KINGSBURY, Henry J. ('21), Ch. & Sales Engr., Hammond Mchy. Bldrs., Inc.; *for mail*, 623 W. Cedar St.
NORMAN, Earl E. ('30), Dir., Dept. Pub. Utilities. City of Kalamazoo, City Hall.

LAKE LINDEN

McINTOSH, Robt. ('13), Supt. Mills, Calumet & Hecla Consltd. Copper Co.
VIGELIUS, F. W. ('20; '26; '35).

LANSING, Detroit Section

BRUSH, Gorton W. ('29), Bridge Designer, State of Mich. Highway Dept., Lansing; *for mail*, 162 Milford St., E. Lansing.
DISTEL, Robt. E. (J'31), M. E., Distel Htg. Equip. Co., 404-406 Kalamazoo Plaza; *for mail*, Box 133.
ECKERT, Otto E. ('30), Gen. Mgr., Bd. of Water & Elec. Light Commissioners; *for mail*, 919 W. Michigan Ave.
MORSE, Jas. W. ('30; '35), Ch. Engr., Lansing Div. of John Bean Mfg. Co., Lansing; *for mail*, 1015 Short St., E. Lansing.
THOMAS, Horace T. ('09), Life Member; Engr., Reo Motor Car Co., S. Washington Ave.; *for mail*, 114 Walnut St., S.
VANDERLIP, Peter J. (J'34), Engr., Oil Htg. Co., 206 S. Grand Ave.
WILFORD, Jas. W. ('22), c/o Melling Forge Co.

LINCOLN PARK, Detroit Section

BROWN, Norton M. (J'34), M. E., Plant Engrg. Dept., Sharples Solvents Corp., 4700 Biddle, Wyandotte; *for mail*, 1662 Chandler Ave., Lincoln Park.

LUDINGTON, Peninsula Section

STARKE, Otto A., Jr. (J'28), M. E., Star Watch Case Co.; *for mail*, 507 E. Ludington Ave.

MANISTEE, Peninsula Section

RAY, Thos. ('23), Pres., Manistee Iron Wks. Co.; *for mail*, 339—2nd St.

MARQUETTE

GRISWOLD, Nelson D. (J'24), Ch. Engr., Charge Design & Constr., Cliffs Dow Chem. Co.; *for mail*, 220 E. Ridge.

MENOMINEE

OKSEN, Hans C. ('21), Supt., Superior Sugar Co.; *for mail*, 1701 Stephenson Ave.
PRESCOTT, Curry S. ('21), Pres., Prescott Co.

MIDLAND, Detroit Section

ASHMUN, Louis H. ('17; '26; '35), Retired Cons. Engr., Dow Chem. Co., E. Main St.; *for mail*, 315 George St.
BEUTEL, A. P. ('29), Asst. Gen. Mgr. Pipe Fitting, Dow Chem. Co.; *for mail*, 911 Eastman Rd.
FAIRCLOUGH, Hugh (J'27), M. E., Physical Research Dept., Dow Chem. Co.; *for mail*, 1005 Eastman Rd.
GREBE, John J. ('30; '34), Dir. Physical Research, Dow Chem. Co.; *for mail*, 612 E. Pine St.
GRISWOLD, Thos., Jr. ('20), Charge Pat. Dept., Chem. Library, Dow Chem. Co.
HENDERSON, Geo. (J'36), Student, Training Course, Dow Chem. Co.; *for mail*, 407 Jerome St.
HULTIN, Ralph (J'36), Engr., Dow Chem. Co., 505 George St.
McPEAK, Bion D. (J'36), Student Welding Inspr., Dow Chem. Co.; *for mail*, 316 McDonald St.
PIERCE, Jas. E. (J'34), M. E., Research & Design, Dow Chem. Co.; *for mail*, R. F. D. 4.
SALISBURY, Allen (J'29), M. E., Dow Chem. Co.; *for mail*, 209 McDonald St.

MILFORD, Detroit Section

JOHNSTON, R. K. (J'36), Gen. Motors Proving Grounds.

MONROE, Detroit Section

FERTIG, Edw. J. (J'30), Sales Engr., Detroit Stoker Co., 101 Park Ave., New York, N. Y.; *for mail*, Monroe, Mich.

MOUNT PLEASANT, Peninsula Section

HAYNES, Jas. M. (J'30), Gen. Delivery.

MUSKEGON, Peninsula Section

BAKER, Hubert E. ('28), 1752 Jefferson St.
OLSON, Raymond G., Jr. (J'29), Gen. Mgr., Midwest Engrg. Co.; *for mail*, 1321—5th St., Muskegon Heights.
ROBINSON, John L. (J'27), Gen. Mgr., Charge Prod. & Opera., W. Mich. Consumers Co.
SPILLMAN, Harry (J'10), Mgr., Continental Gas & Oil Co., 205 Market St.; *for mail*, Occidental Hotel.

PERRY, Detroit Section

COLBY, Elmer W. (J'35), P. O. Box 262.

PORT HURON, Detroit Section

ACHESON, Howard A. ('24; '34), Pres., Acheson Colloids Corp., Washington Ave.
DRUMMOND, A. S. (J'35), Box 12, Rt. 2.
GRIFFIN, Boyd (J'31), Jr. Engr., Detroit Edison Co., 2000—2nd Ave., Detroit; *for mail*, 1115 St. Clair St., Port Huron.
ROGERS, Nellie Scott (A'26), Retired; Lake Shore Dr.
SCHUMANN, Edw. A., Jr. (J'35), Jr. Engr., Prod., Detroit Edison Co.; *for mail*, P. O. Box 358.
YOUNG, R. Hence ('26; '34; '35), Asst. to Plant Engr., Mueller Brass Co., 1925 Lapeer Ave.; *for mail*, 1207 Court St.

RIVER ROUGE, Detroit Section

KALES, Wm. R. ('94; '14), Pres., Whitehead & Kales Co., 58 Haltiner Ave., River Rouge; *for mail*, 1824 Union Guardian Bldg., Detroit.
TURNBULL, Geo. B. ('14; '23), V. P. & Gen. Mgr., Great Lakes Engrg. Wks.
VARIAN, Howard M. ('16; '25), Ch. Engr., Great Lakes Engrg. Wks., River Rouge; *for mail*, 22042 Morley Ave., Dearborn.

ROGERS CITY, Detroit Section

MUNSON, John G. ('17), Pres., Mich. Limestone & Chem. Co., also, Bradley Transportation Co., 170 Woodward Ave., E. Rogers City.
STANBROOK, Reginald C. ('26), Power Engr., Mich. Limestone & Chem. Co.

ROYAL OAK, Detroit Section

ANDRE, Eugene R. (J'36), 26373 Hendrie Blvd.
SCHOOLEY, Otis L. ('30; '35), Inspr. & Engr., Mutual Boiler Ins. Co. of Boston, Mass.; *for mail*, 3560 Royal Ave., Berkeley, Royal Oak.

SAGINAW, Detroit Section

BAUER, Carl J., Jr. (J'32), Asst. Personnel Dir. & Safety Engr., Saginaw Malleable Iron Div., Gen. Motors Corp.; *for mail*, 17 W. Hannum Blvd.
BICKEL, Herman H. ('27; '34), Ch. Engr., Wickes Boiler Co.; *for mail*, R. 6, West Side.
BOHN, Adolph R. (J'34), Engr., Mch. Design & Erection, Baker Perkins Co., Inc.; *for mail*, 539 S. Warren.
LISKOW, Bernard H. ('14), Plant Engr., Chevrolet Grey Iron Fdy., N. Washington St.; *for mail*, 514 Atwater St.
McKENNA, Jos. F. (J'35), Ch. Draftsman, Wickes Boiler Co.; *for mail*, 1022 Owen St.
McKERNAN, Hugh J. (J'25), Efficiency Supvr., Consumers Power Co., Box 315; *for mail*, 817 Cherry St.
MUELLER, Max. W. ('20), Ch. Engr., Charge Flour & Bread Handling Dept., Baker Perkins Co., Inc., Hess Ave.; *for mail*, 615 S. Jefferson Ave.
SCHUPP, Arthur A. ('17; '23; '28), Gen. Mgr., Fredericksen Co., 930 S. Water St.
VOGT, Herman W. (J'36), Shop Apprentice, Wilcox-Rich Corp.; *for mail*, 1021 Ames St.
WILLCOX, Geo. B. ('95; '08), Cons. Engr., Pat. Solicitor, 900 S. Warren Ave.
WILLITS, Chas. W. ('36), Sales Mgr., Mitts & Merrill; *for mail*, 235 Lockwood St.
WITHERIDGE, David E. (J'36), 746 S. 4th Ave.

ST. CLAIR, Detroit Section

JOHNSTON, Geo. X. ('27; '35).

ST. CLAIR SHORES, Detroit Section

NELSON, Emil Andrew ('13), Ardmore Park.

ST. JAMES, Peninsula Section

GALLAGHER, E. Earl (J'33).

ST. JOSEPH, St. Joseph Valley Section

SIDMORE, Benj., Jr. ('24), Pres., Skidmore Corp., Box 158.

WAKEFIELD

GARSKI, Alex. (J'36), 709 Hancock St.

WEST BRANCH, Detroit Section

WYRICK, Howard B. (J'33), Engr., Charge Dist., Producers Refining Inc., Box 443.

WYANDOTTE, Detroit Section

RUIZ, Jos. J. ('29; '35), M. E., Design & Maint., Mich. Alkali Co.; *for mail*, 2643—3rd St.
SAUNDERS, C. B. ('33; '35), Designer, Engrg. Dept., Pa. Salt Co.; *for mail*, 2234 Biddle St.
SMITH, Robt. Wm. ('14), Constr. Engr., Mich. Alkali Co.; *for mail*, 80 Vine Wood Ave.

MINNESOTA

CAMBRIDGE, Minnesota Section

BJORKLUND, Edw. E. (J'31), Mgr., Cambridge Woolen Mills.

COLD SPRING, Minnesota Section

STEIL, Marcus J. (J'29).

DEER RIVER

PINKHAM, Burton N. (J'33), Company 4709, Civilian Conservation Corps.

DULUTH

CORNISH, Wm. R. ('13; '26), Am. Steel & Wire Co., Morgan Park.
FOSTER, Chas. ('17), Cons. Engr., Foster & Wahlberg, 316 Medical Arts Bldg.
SPOTTS, Herbert J. (J'28), Oper. Engr., No. Cold Storage, 7th & Railroad Sts.; *for mail*, 1721 E. 3d St.

FAIRMONT, Minnesota Section

RIPKEN, Wm. H. (J'33), Exper. Dept., Fairmont Ry. Motors, Inc.; *for mail*, 190 Woodland Ave., S.

FERGUS FALLS

WELCH, Geoffrey W. ('35; '35), Ch. Engr., Otter Tail Power Co.

INTERNATIONAL FALLS

KUSNIEREK, Clement J. (J'29), P. O. 803.
NELSON, Raymond A. (J'35), 927 Riverside Dr.

MINNEAPOLIS, Minnesota Section

AKINS, Clifford M. (J'28), V. P., Marquette Mfg. Co., 401-19 Johnson St., N. E.
ASHENDEN, Ernest W. ('21), Ch. M. E., Wm. Bros Boiler & Mfg. Co., Lower Nicollet Island; *for mail*, 945—17th Ave., S. E.
BLUMERS, Fred'k (J'36), M. E., Asst. on Process Improvement, Gen. Mills, Inc.
BOUVIER, Geo. A. ('36), Dir. Engrg., Minneapolis-Honeywell Regulator Co., 2737—4th Ave., S.; *for mail*, 2615 Park Ave., S.
BROOKE, Wm. E. ('17), Prof., Head Math. & Mechanics, College of Engrg. & Arch., Univ. of Minn.
BROS, C. W. ('30; '35), V. P., Wm. Bros Boiler & Mfg. Co.; *for mail*, 5336—1st Ave., S.
BURLINGAME, Walter S. ('35), Mem. Firm, Burlingame & Hitchcock, 526 Sexton Bldg., Minneapolis; *for mail*, 1231 Van Buren St., St. Paul.
CAMPBELL, Jesse M. (J'29), Instr., M. E. Dept., Univ. of Minn.
CHATFIELD, Howard ('27; '35), Supvg. Engr., Fidelity & Casualty Co. of N. Y., 933 McKnight Bldg.
COBB, Leonard A. ('29), Supt., Steam Plants, No. States Power Co., 15 S. 5th St.
COLVIN, Jas. A. ('15; '25), Supt. Generation, No. States Power Co., 15 S. 5th St.
CRUM, Stephen (J'35), Test Engr., Minneapolis-Honeywell Regulator Co.; *for mail*, 108 E. 24th St.
Du PRIEST, John R. ('11), Prof. M. E., Head Dept., Univ. of Minn.
ERSKINE, Walter H. ('23), Mfrs. Rep., Box 72, Traffic Sta., Minneapolis; *for mail*, 2371 Chilcombe Ave., St. Paul.
FIELD, Emmet J. (J'33), 73 Clarence Ave., S. E.
FORD, Arthur R. (J'20), Asst. Prof. Internal Combustion Engines, Exper. Engrg. Bldg., Univ. of Minn.
FORD, Robt. E. ('19), Partner, Luther Ford & Co., 100 N. 7th St.; *for mail*, 2617 Humboldt Ave., S.
FORFAR, Donald M. (J'13), M. E., Grinnell Co., 240—7th Ave., S.; *for mail*, 4817 Emerson Ave., S.
GARBETT, Benjamin C. (1912), Treas., Design Engr., Twin City Mch. Co.; *for mail*, 416 Oak St., S. E.
GIBBS, Russell E. ('31; '35), Asst. Prof. Steam Engrg., Univ. of Minn.
HERRICK, Carl A. ('12), Assoc. of Math. & Mechanics, Univ. of Minn.; *for mail*, 4120 Sheridan Ave., S.
HOLTBY, Fulton (J'34), Head Instr., Fdy. Practice Dept., Univ. of Minn.
KOEPKE, Prof. C. A. ('29; '35), Assoc. Prof. Indus. Engrg. & Supt. Shops, Univ. of Minn.
LARSON, Jarl E. ('28; '35), M. E., Minneapolis-St. Paul Sanitary Dist. Project, Pub. Wks. Admin., 413 Old P. O. and Federal Courts, St. Paul; *for mail*, 4936 Penn Ave., S., Minneapolis.
MACFARLANE, Warren C. ('19), Pres., Gen. Mgr., Minneapolis-Moline Power Implement Co.
MARTENIS, John V. ('13), Assoc. Prof. Mch. Design, Univ. of Minn.; *for mail*, 4800 Bloomington Ave.
MEYER, Adolph F. ('21), Pres. & Cons. Engr., Meyer Governor Co., 628 Metropolitan Bank Bldg.
MJOLSNES, Elliot L. (J'35), 3241 Stevens St.
MORTON, Harold S. ('14; '22), 4330 Wooddale Ave.
MOYER, Amos F. ('14; '21), Ch. Engr., Charge Design, Toro Mfg. Co., 3042 Snelling Ave., *for mail*, 117 Arthur Ave., S. E.
NEMEC, Edw. J. (J'33), 3443 Columbus Ave.

NEWTON, Alwin B. (J'31), Engr., Charge Refrigeration & Air Conditioning Control Devel., Minneapolis-Honeywell Regulator Co.; *for mail,* 18 W. Rustic Lodge Ave.
NORTHFIELD, Glenn H. (J'31), Maint. Engr., L. W. Northfield Equip. Co., 2542 Central Ave., N. E.
OVESTRUD, Melvin (J'17), V. P., Supt., Pioneer Gravel Equip. Mfg. Co., 1515 Central Ave.; *for mail,* 3825 Chowen Ave., S.
POWELL, Knox A. ('23; '25; '33), Plant Research Engr., Minneapolis-Moline Power Implement Co., 29th & Minnehaha; *for mail,* 1008—18th Ave., S. E.
PRIEDEMAN, Geo. W. ('21), Pres. & Treas., Minneapolis Ornamental Iron Co., 143—27th Ave., S. E.
RANK, Homer L. ('18; '22), Sales Mgr., Pulverizer Dept., Strong-Scott Mfg. Co., N. W. Terminal; *for mail,* 5333—3d Ave., S.
RICHARDS, Chas. Russ ('92; '01; F'36), Manager, '18-'21, 1725 Summit Ave.
ROBERTSON, Burton J. ('21), Assoc. Prof., Internl. Combustion Engines, Univ. of Minn.
ROBINSON, Edmund Marriott ('27; '35), Engr., Travelers Ins. Co., Hartford, Conn.; *for mail,* 1929 Freemont Ave., S., Minneapolis, Minn.
ROLLINS, Lewis M. ('16; '19), V. P., Rollins Inc., 2000 Portland Ave.; *for mail,* 615 W. 35th St.
ROSE, Fred W. ('13; '17), V. P., Treas., Rose & Harris, Engrs., Inc., 416 Essex Bldg.
ROWLEY, Frank B. ('11; '13; '18), Prof., M. E., Dir., Exper. Engrg. Labs., Univ. of Minn.; *for mail,* 4801 E. Lake Harriet Blvd.
RYAN, Jas. J. (J'26), Asst. Prof. Mch. Design, Univ. of Minn.
RYNDA, Jos. T. ('32), Engr., Maint. & Power, Commander-Larabee Milling Co., 202 S. W. Elm Ave., Montgomery; *for mail,* 733 Marquette Ave., Minneapolis.
SCHULTZ, Kenneth Wm. ('26; '32; '35), 3203 Penn Ave., N.
SHOOP, Chas. F. ('14), Prof. Steam Engrg., Univ. of Minn.
SHULTZ, Emmett O. ('29; '35), Instr., Inst. of Tech., Univ. of Minn.
SMITH, Lloyd Lyman ('20), Mgr., Lloyd L. Smith Power Plant Equip., 605 Plymouth Bldg.
SODERSTROM, Olov A. ('25; '30), V. P., Charge Mfg., Elec. Mchy. Mfg. Co., 1331 Tyler St.
SOUBA, Wm. H. ('14; '17), 4601 Edina Blvd., Country Club Blvd.
STRAUB, Lorenz G. ('32; '35), Prof. of Hydraulics, Univ. of Minn.
THAYER, Paul W. ('18; '24), Engr., Charge Design & Constr., Am. Gas Constr. Co., 316 Frontenac Bldg.; *for mail,* 2808 Fremont Ave., S.
VAN CLEVE, Horatio P. ('12; '16), 516—6th Ave., S. E.
VANSELOW, J. C. ('27; '35), Shop Supt., West. Elec. Co., Inc., 900 Laurel Ave.; *for mail,* 5245 Chowen Ave.
VAN WYCK, Philip S. ('19; '27; '35), Dept. Head, Mch. & Auto Depts. Dunwoody Indus. Inst.; *for mail,* 417 Oliver Ave., S.
WARMINGTON, Thos. J. ('20; '27; '35), Asst. Ch. Engr., Wm. Bros Boiler & Mfg. Co., Nicollet Island.
WATSON, Harold H. ('28), Gen. Supt. Constr., No. States Power Co., 15 S. 5th St.
WILCOX, Hugh B. ('23; '35), Assoc. Prof., Mathematics & Mechanics, Univ. of Minn., Rm. 207, Main Engrg. Bldg.

NEW ULM, Minnesota Section

MULLIN, Marcellus (J'29), Elec. Light & Water Wks. Dept., City of New Ulm, New Ulm; *for mail,* Marshall.

PROCTOR

BOHANNON, Geo. W. (J'26), M. E., Duluth, Missabe & Northern Ry. Co.

ST. CLOUD

WEBER, O. L. E. ('95; '05), 201 S. 4th St.

SAINT PAUL, Minnesota Section

BOHN, Gebhard C. (A'15), Pres., Bohn Co., 1588 University Ave.
BRENEMAN, Louis A. ('27), M. E., Donovan Constr. Co., 405 Builders Exchange Bldg.; *for mail,* 1787 Jefferson Ave.
CURRY, Ezra B. ('24; '35), 1203 Laurel Ave.
DOTY, Paul ('91; '04; F'36), Manager, '26-'29, Vice-President, '29-'31; President, '34; Chmn., Bd. of Registration, Engrs., Archs., Land Surveyors, 626 New York Bldg.; *for mail,* 427 Portland Ave.
ELSNER, Wm. H. ('20; '35), M. E., Great No. Ry., 4th & Jackson St.; *for mail,* 1456 Osceola Ave.
ENDICOTT, George F. ('28), M. E., No. Pac. Ry. Co., 176 E. 5th St.
FISCHER, Howard L. ('30), Pat. Atty., Engr., W-1767 First Natl. Bank Bldg.
FRAWLEY, Patrick J. ('26), Ch. Engr., High Bridge Sta., No. States Power Co.; *for mail,* 1979 Palace St.
GETSUG, Bertram (J'34), M. E., Brown Sheet Iron & Steel Co., 964 Berry Ave.; *for mail,* 609 Marshall Ave.
GRANT, Irving G. (J'31), High Bridge Steam Sta., No. States Power Co.
GRIMM, Eugene L. ('23), Asst. to Gen. Mech. Supt., No. Pac. Ry. Co., 1134 No. Pac. Ry. Bldg.
HOWARD, Edgar S. (J'35), Time Study Dept., Minn. Min. & Mfg. Co., Forest & Fauquier Sts.
JOHNSON, Ernest M. ('19; '35), Minn. Min. & Mfg. Co.; *for mail,* St. Paul Athletic Club.
JOHNSON, Howard S. ('29), V. P., Charge Sales, Am. Hoist & Derrick Co.
LAWATSCH, Frank R. ('14; '35), Asst. Engr., Opera. & Maint., U. S. Engrs. Office, 615 Commerce Bldg.
MARSH, G. Everett (J'27), Sales Engr., Bailey Meter Co., 2112 Hartford Ave.
MOONEY, Geo. M. (J'32), 418 Beacon Ave.
SHALLENBERGER, Geo. G. ('19; '35), Secy.-Treas. Mgr., Great No. Iron Ore Properties, Room W-1481, 1st Natl. Bank Bldg.
STAUDE, Edwin G. ('08; '17), Pres., E. G. Staude Mfg. Co., 2675 University Ave., St. Paul; *for mail,* 2232 Lake of Isles Blvd., Minneapolis.
STERNAL, Norbert J. (J'34), Engr., Drafting & Design, Minn. Min. & Mfg. Co., Forest & Fauquier Sts.
THOMAS, Wm. A. ('25; '35), Engr. 3M Co.; *for mail,* 2120 Berkley St.
WARD, Chas. ('32), Pres., Brown & Bigelow, Quality Park.
WASHBURN, Harold O. ('28), Gen. Supt., Am. Hoist & Derrick Co., 63 S. Robert St.
WILLIAMS, Howard O. ('30; '33), Office Engr., Edw. E. Johnson, Inc., 2304 Long Ave., St. Paul; *for mail,* 2616—15th Ave., S., Minneapolis.
WOOD, Jas. A. (J'35), 1996 Terrace Park.
WOOD, Wm. R. ('13), Asst. Gen. Supt. Motive Power, Great No. Ry. Co.
WUNDERLICH, Milton S. ('20; '26), Charge, Research, Testing, Insulite Co., 1100 Builders Exch., Minneapolis; *for mail,* 545 Mt. Curve Blvd., St. Paul, Minn.

TWIN VALLEY

GRUTLE, Reinert O. (J'35), Electrician, Otter Tail Power Co., Jamestown, N. D.; *for mail,* Twin Valley, Minn.

MISSISSIPPI

ACKERMAN

GILLIAM, C. C. (J'32).

BROOKHAVEN

MILLS, Fulton S. (J'34), 539 S. Jackson St.

FRENCH CAMP

CURTIS, Arthur B. (J'36).

GREENVILLE

WARD, J. W., Jr. (J'36), 1303 Washington Ave.

GREENWOOD

CRENSHAW, R. A. (J'34).

GULFPORT

HOLLOWAY, Walter (J'23), Dist. Engr., Miss. Power Co., Gulfport; *for mail,* 34 Washington Ave., Ocean Springs.

HATTIESBURG

GREEN, John Orne ('32), M. M., Miss. Cent. R. R. Co.; *for mail,* 302—22nd Ave.
PATTERSON, C. B. ('22; '35), Power Supvr., Hercules Powder Co., Wilmington, Del.; *home address,* 611 Corinne St., Hattiesburg, Miss.

JACKSON

BARKLEY, Walter R. ('24; '25; '35), Miss. Power & Light Co.
McAULEY, McGill M. ('29), V. P., Fed. Pharmacal Co., Inc., W. Bell St. & I. C. R. R.

KILN

ROSSEAU, Francis V. (J'33), Civilian Conservation Corps, Co. 1484, Camp P-52.

LAUREL

LESNIAK, F. G. (J'27), Asst. Ch. Engr., Masonite Corp.
MASON, Wm. H. ('01; '13), V. P., Masonite Corp.
PETTINGILL, Fred M. ('28), Design Engr., Masonite Corp.; *for mail,* P. O. Box 921.

NATCHEZ

RITNOUR, Luther Clifton ('32), Plant Mgr., Ch. Engr., Natchez Ice Co.; *for mail,* 305 Linton Ave.

SARDIS

SHORT, R. M. (J'36), Asst. Inspr., U. S. Engrs., Sardis; *for mail,* Crenshaw.

STATE COLLEGE

CARPENTER, Randle C. ('12), Prof. M. E., Supt. Power Plant, Miss. State College.
VARNADO, Osmond D. M. ('24; '35), Prof. Steam & Gas Engrg., Miss. State College.

VICKSBURG

STEPAN, Theo. E. (J'36), Jr. Engr., Charge Mech. Design for Dam, U. S. Engr. Office, Federal Bldg.; *for mail,* 1503 Chambers St.

MISSOURI

BONNE TERRE, St. Louis Section

SICKA, Louis T. ('12), Gen. Mgr., St. Joseph Lead Co.; *for mail,* P. O. Box 231.

CAPE GIRARDEAU

KIMBALL, Clinton ('35), Retired; 224 N. Lorimier St.

CENTRALIA

ZUERL, Chas. Donald (J'36), Draftsman, Chance Co.; *for mail,* 303 S. Jefferson St.

CHILLICOTHE

CRENSHAW, Bransford W. ('24; '34; '35), Gen. Mgr., Chillicothe Municipal Utilities; 711 Washington St.; *for mail,* 1407 W. Clay St.

COLUMBIA

McCLAIN, Raymond G. (J'32), Engr., Charge Design, McClain Furniture Co., 912—14 E. Walnut St.; *for mail,* P. O. Box 217.
SCORAH, Ralph L. (J'26), Asst. Prof. M. E., Engrg. Labs., Univ. of Mo.; *for mail,* 117 Stewart Rd.
SELVIDGE, Robt. W. ('27), Chmn. Dept. M. E., Univ. of Mo.
WHARTON, Jas. R. ('14), Assoc. Prof. M. E., Univ. of Mo., 139 Engrg. Hall.

CRYSTAL CITY, St. Louis Section

WRIGHT, Miles S. (J'30), Effic. Engr., Pittsburgh Plate Glass Co.; *for mail,* Box 224.

FULTON

BAKER, B. M. (J'35).

IANTHA

THORPE, Clare J. (J'36).

JEFFERSON BARRACKS, St. Louis Section

EKLUND, Karl F. (J'32), Officer, U. S. Army, Jefferson Barracks, Mo.; *for mail,* 836 Washington Blvd., Oak Park, Ill.

JOPLIN

IREY, Geo. W. ('30), Dir. & Supt. Plants, Empire Dist. Elec. Co., 602 Joplin St., Joplin, Mo.; *for mail,* Riverton, Kan.

KANSAS CITY, Kansas City Section

ATWATER, Harry A. ('14; '25), Ch. Engr., Combustion Equip. Co., 1820 Cherry St.; *for mail,* 641 W. 67th St.
BARNES, Murle C. (J'31), Ch. Draftsman, Marley Co., 1915 Walnut St.
BARZEN, Richard G. ('24; '30; '35), Secy., Treas., Gen. Mgr., Sterling Mchy. Corp., 411 Southwest Blvd.
BECK, Chas. E. ('11; '18; '35), Sales Engr., Busch-Sulzer Bros.-Diesel Eng. Co., 2nd & Utah Sts., St. Louis; *for mail,* 6534 Pennsylvania Ave., Kansas City.
BETTIS, Alex. E. ('15; '35), V. P., Engrg. & Constr., Kansas City Power & Light Co., 1330 Baltimore Ave.
BROWN, Chas. Ellsworth ('30), Assoc. Engr., Burns & McDonnell Engrg. Co., 107 W. Linwood Blvd.
BROWNE, Leland W. ('32; '35), V. P., Darby Corp., 923 N. 3rd St., Kansas City, Kan.; *home address,* 647 W. 59th St., Kansas City, Mo.
BUTLER, Clarence A., Jr. (J'25), United Light & Power Engrg. & Constr. Co., Rm. 1908, 106 W. 14th St.
CHRISTIE, Rex W. (J'35), 6300 Morningside Dr.
CRAIN, Henry L. (J'28), Testing Engr., Kansas City Power & Light Co., 115 Grand Ave.

DARNOLD, Edgar E. ('27), Ch. Engr., Kansas City Terminal Ry. Co., Union Sta.; *for mail* 3942 Mercer St.
DOWNES, Nate W. ('11; '17; '25), Ch. Engr., Supt. Bldgs., Sch. Dist. of Kansas City, Finance Bldg.
EDMISTON, Maurice O. ('25; '35), Lub. Engr., Sinclair Refining Co., Chicago, Ill.; *for mail* 7200 Summit St., Kansas City, Mo.
ESSEX, Thos. J. ('30), Oper. & Maint., Kansas City Power & Light Co.; *for mail*, 4944 Lydia Ave.
GOLD, Saml. B. ('28), Ch. Engr., Supt., Weber Eng. Co., 12th & Winchester Ave., Kansas City; *for mail*, 1210 W. Waldo Ave., Independence.
HADLEY, Stanton A. ('21), Spec. Rep., Oil & Gas Power Div., Worthington Pump & Mchy. Corp., 1004 Baltimore Ave.
HAHN, Raymond P. (J'33), Asst. Testing Engr. Kansas City Power & Light Co., 115 Grand Ave.; *for mail*, 3526 Olive St.
HALDEN, Herbert O. (J'24), 21 Manufacturers Exchange Bldg.
HARRINGTON, John Lyle ('03; F'36), Vice-President, '20-'22; President, '23; Cons. Engr. Harrington & Cortelyou, 1004 Baltimore Ave.
HEMBER, I. M. (J'29), 7524 Grand Ave.
HOLZBAUR, Fred'k J. ('20; '25; '28), Ch. Engr & Mech. Supt., Stand. Oil Co. of Ind., Sugar Creek; *home address*, 6227 McGee St., Kansas City, Mo.
HOWARD, Ernest E. ('13), Partner, Ash-Howard-Needles & Tammen, 1012 Baltimore Ave.
HUTCHISON, F. C. (J'27), 910 Baltimore Ave.
JOSLYN, Ray O. ('31), Pres., Layne-Western Co. 215 Pershing Rd.
JOWETT, Edwin ('21), 1240 W. 64th St.
KEETH, Jacob A. ('19; '25; '31), M. E., Asst. to V. P., Kansas City Power & Light Co., 1330 Baltimore Ave.
KIRKWOOD, Arthur C. ('23; '36), Engr., Burns & McDonnell Engrg. Co., 406 Interstate Bldg.; *for mail*, 5632 Charlotte St.
KRAMER, A. A. ('20), Pres., Columbian Steel Tank Co., 1509 W. 12th St.
LOWRY, W. Malcolm ('21), V. P., Treas., Henrici Lowry Engrg. Co., 114 W. 10th St.
MAILLARD, Albert L. ('25), Cons. Engr., Head Air Conditioning Dept., Kansas City Power & Light Co., P. O. Box 679.
MARTIN, Elmer C. ('17; '25; '35), Mem. Firm Ewing & Martin, 214 Finance Bldg.
MATHEWS, W. L. (J'30), Designing Engr., Stand. Oil Co., Sugar Creek; *for mail*, 1826 Spruce Ave., Kansas City.
McCRACKEN, Stanley P. (J'34), Jr. Engr., U. S Engrg. Dept., 8th & Minnesota Sts.; *for mail* 6237 E. 15th St.
McDONALD, Edw. L. ('28), Effic. Engr., Kans. City Power & Light Co., 1330 Baltimore Ave.; *for mail*, 5001 Virginia Ave.
MERKEL, Wm. H. ('25), Sales Engr., Hadfield-Penfield Steel Co.; *for mail*, Baltimore Hotel.
MILLER, Howard E. (J'35), M. E., Draftsman. E. K. Campbell Htg. Co., 2445 Charlotte St.; *for mail*, 3717 Harrison Blvd.
MILLER, Newby L. (J'28), Asst. Test. Engr. Northeast Sta., Kansas City Power & Light Co.; *for mail*, 3608 Benton Blvd.
MOONEY, Weldon ('29; '35), Sales Engr., English Bros. Mchy. Co., 410 W. 5th St.; *for mail* 5601 Brooklyn Ave.
MULLERGREN, Arthur L. ('18; '28), Cons. Engr., 202 Fairfax Bldg.
NEW, Wm. E. ('13), M. M., Kansas City Terminal Ry., 2530 Southwest Blvd.; *for mail*, 4123 Holly St.
OHLER, Ralph E. (J'34), Sales Mgr., Sterling Mchy. Corp., 411 Southwest Blvd.; *for mail* 2451 Poplar St.
PETERSON, E. W. (J'34), 8700 Brooklyn Ave.
PETERSON, V. A. (J'35), Sales Engr., Elliott Co. Pittsburgh, Pa.; *for mail*, 1107 W. 45th St., Kansas City, Mo.
PORTER, Jos. F. ('22), Pres., Kansas City Power & Light Co., 1330 Baltimore Ave.
PRITCHARD, John F. ('23), Pres., J. F. Pritchard & Co., 528 Dwight Bldg.
ROLLINS, Wm. B. ('29), Propr., W. B. Rollins & Co., 339 Railway Exchange Bldg.
SHOEMAKER, Guy T. ('26), United Light & Power Engrg. & Constr. Co., 1330 Baltimore Ave., P. O. Box 679; *for mail*, 1010 W. Gregory Blvd.
SPRINGE, Walter (A'23), Mgr., Combustion Engrg. Co., Inc., 461 Bd. of Trade Bldg.
STALDER, Lee R. ('29; '35), Weber Eng. Co., 11th & Winchester St., Kansas City; *for mail*, P. O. Box 297, Independence.
STOLZ, Paul L. ('21), V. P., Charge Sales M. E. Charge Maint., Anderson-Stolz Corp., 1535 Walnut St.
SUTHERLAND, Richard V. ('36), Ch. Engr., Butler Mfg. Co., 7400 E. 13th St.; *for mail*, 2718 Linwood Blvd.
TODD, Paul E. ('23; '35), Designer, United Light & Power Constr. & Engrg. Co., 14th & Baltimore St.
VEATCH, N. T., Jr. ('21), Mem. Firm, Black & Veatch, Cons. Engrs., 4706 Broadway.
WALTER, Jos. A. ('26), Asst. Ch. Engr. & Supt., Kansas City, Mo., Water Dept., City Hall; *for mail*, 3816 Montgall.
WIDAU, Wm. E. (J'21), Mid-West. Mgr., Elliott Co., Fairfax Bldg.; *for mail*, 1016 W. 70th Terrace.
WOODSON, Riley D. (J'35), Asst. Engr., Black & Veatch, Cons. Engrs., 4706 Broadway; *for mail*, 4109 Kenwood St.
ZIMMERMAN, Hayden (J'34), M. E., Kansas City Bridge Co., 215 Pershing Rd.
ZIMMERMAN, R. M. (J'36), Engr., T. W. A., Inc. 10 Richards Rd.

KIRKWOOD, St. Louis Section

ROSENFELT, Saml. D. ('21; '35), Dist. Sales Mgr., Franklin Ry. Supply Co., Inc., 60 E. 42nd St., New York, N. Y.; *for mail*, 160 Cornelia Ave., Kirkwood, Mo.
SCOTT, Lewis L. ('18), Pres., Scott-Newcomb, Inc., 1922 Pine St., St. Louis; *for mail*, 10 Cornelia Ave., Kirkwood.

MEXICO

SMITH, Chas. A. ('26; '30; '35), Ch. Engr., Wks. Mgr., Mexico Refractories Co., P. O. Box 271.

MOUNTAIN GROVE

MEANS, F. Wayne (J'34), 719 E. State St.

ROLLA

JACKSON, R. O. ('23), Prof. M. E., Mo. Sch. of Mines & Metal.; *for mail*, P. O. Box 307.

ST. CHARLES, St. Louis Section

CLARKE, Allen W. ('19), M. E., Am. Car. & Fdy. Co.
PRENDERGAST, Wm. A. (J'35), Bridge Inspc. Mo. State Highway Dept.; *for mail*, 330 Madison St.

ST. JOSEPH, Kansas City Section

D'IMOR, E. J. ('34; '35), Engr., Aitchison-Richmond Supply Co., 209-211 S. 4th St.; *for mail*. St. Charles Hotel.

ST. LOUIS, St. Louis Section

ACKERMAN, Frank ('12; '21), V. P., Curtis Mfg. Co.; *for mail*, 7384 W. Moreland.
ADDICKS, Mentor C. (J'28), Asst. to Oper. Mgr., Mo. Portland Cement Co.; *for mail*, 5743 Cabanne Ave.
ADOLPHSON, John F. (J'29), M. E., Charge Dept. Maint. & Opera., Laclede Gas Light Co., 526 E. Catalan St.; *for mail*, 5523A Tennessee Ave.
ADOLPHSON, Roy T. (J'34), Asst. Quality Engr., St. Louis Lamp Wks. of Gen. Elec. Co., 6251 Etzel St., St. Louis; *for mail*, 8321 Flora St., St. Louis County.
ANDERSON, Hallam H. ('24; '28), Gen. V. P., Shell Petroleum Corp., Shell Bldg.
ANDREW, Lowell R. (J'25), Owner & Oper., Andrew Mfg. Plant, 9640 Tennyson Ave.
BAKER, Norman L. ('15), Sales Mgr., W. Va. Coal Co. of Mo., 1407 Boatmens Bank Bldg.; *for mail*, 7042 Forsythe Blvd.
BARRETT, Andrew E. ('31; '35), Spec. Mchy. Design, 4355 Forest Park Blvd.
BAUSCH, Fred'k E. ('04), Sales Engr., 1605 Chemical Bldg.; *for mail*, Ellington Apts., 4961 Laclede Ave.
BEHLE, Edgar H. (J'31), Prod. Engr., Charge Stands. Dept., Rice-Stix Dry Goods Co., 417 N. 10th St.; *for mail*, 23 Lee Ave., Clayton.
BERGER, Franz A. ('09), Asst. Prof. M. E., Washington Univ.
BEST, Jesse L. ('14; '21), Ch. Operating Engr., Anheuser-Busch, Inc., 721 Pestalozzi St.; *for mail*, 4527 Magnolia Ave., St. Louis, Mo.
BIRD, Ralph C. ('22), Sales Engr., Williams Pat. Crusher & Pulverizer Co., 2701-2723 N. Broadway, St. Louis; *for mail*, 837 Atalanta Ave., Webster Groves.
BLISS, Wm. C. ('20; '25), Supt., Scullin Steel Co., 6700 Manchester Ave.
BOYLES, Robt. M. ('23; '30; '33), Cons. Engr., 525 Internatl. Bldg.
BRADLEY, Eugene P. ('18), Pres., Hester-Bradley Co., 2835 Washington Blvd.
BRANCH, Arthur M. ('25), Cons. Engr., Rm. 204, 319 N. 4th St.
BRANDT, Frank C. ('27; '33), Babcock & Wilcox Co., 1809 Ry. Exchange Bldg.
BRAUN, John B. (J'34), Asst. Engr., St. Mary's Hospital, 6420 Clayton Rd.
BRISCOE, C. B. (J'33), M. E., Dept. of Pub. Utilities, City of St. Louis, Rm. 311, City Hall; *for mail*, 4453 Russell St.
BROWN, Alfred W. (A'29), Pres., Hall & Brown Wood Working Mch. Co., 1913 N. Broadway.
BRYAN, Walter E. ('14; '20), Supt. Power, St. Louis Pub. Serv. Co., 3624 Vista Ave.
BUSSE, F. Ewald ('13), 4577 Athlone St.
CASKEY, Myron W. (J'29), 3517 Central Pl.
COLLEY, Chas. J. ('24), Effic. Engr., Monsanto Chem. Wks., 1800 S. 2nd St.
COMPTON, Paul (J'34), 5645 Cates Ave.
COMPTON, Robt. B. ('22;'29), Mem. Staff, Stevenson, Jordan & Harrison, 440 Murphy Bldg., E. St. Louis, Ill.; *home address*, 4626 Tower Grove Pl., St. Louis.
COPP, Ralph ('26), Supv. Engr., Pevely Dairy Co., 1001 S. Grand Blvd.; *for mail*, 4268 Arsenal St.
CORBY, J. B. (A'21), Pres., Corby Supply Co., 3946 W. Pine Blvd.
CRAFT, Harry W., Jr. (J'34), M. E., Charge Maint., Procter & Gamble Mfg. Co., 169 E. Grand St.; *for mail*, 4266a Red Bud Ave.
DANIELSEN, John E. ('25), M. E., Monsanto Chem. Wks., 1800 S. 2nd St., St. Louis; *for mail*, 407 Lee Ave., Webster Groves.
DAVIS, Edw. W. ('20), Southwest. Mgr., Westinghouse Air Brake Co., 1932 N. Broadway.
DICKEY, Donald E. (J'31), Research Engr., Broderick & Bascom Rope Co., 4203 N. Union Blvd., St. Louis; *for mail*, 121 Peeke Ave., Kirkwood.
DIEDRICH, Wm. C. (J'28), Estimator, Midwest Piping & Supply Co., 1450 S. 2nd St.; *for mail*, 3649A Wilmington, St. Louis, Mo.
DILLON, Edw. L. ('09), Cons. Engr., 702 Wainwright Bldg.; *for mail*, 7450 Teasdale Ave.
DOBYNE, Stevenson A. ('15; '35), Pres., Champion Shoe Mchy. Co., 3711 Forest Park Ave.
DOERING, Walter C. (A'33), V. P., Sales, Am. Steel Fdys., 1719 Ry. Exchange Bldg.
DON, Julius M. (J'35), 5656 Waterman Blvd.
DOOLITTLE, Jas. H. ('30), Mgr., Aviation Dept., Shell Petroleum Corp., 508 Shell Bldg.
DUTTON, D. W. (J'35), 4043 Botanical Ave.
ECKERT, Arthur C. ('13; '19), Pat. Lawyer, 511-15 Title Guaranty Bldg.
EICHELSBACH, Geo., Jr. (J'34), 4457a Nebraska St.
EMORY, John Brooks ('19), V. P., Heine Boiler Co., 5319 Shreve Ave.
ESKIN, Samuel G. (J'26), Engr., Charge Devel. & Design, Am. Thermometer Co., 2917 Clark Ave.
EVANS, Lawrence E. (J'26), Mgr., St. Louis Office, Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio; *for mail*, 6442 Lindenwood Pl., St. Louis, Mo.
EWART, Wm. M. ('19; '33), Factory Mgr., Carter Carburetor Corp., 2840 N. Spring Ave.
FIXMAN, Carl Marx (J'34), Engr., Design of Arches & Walls, Laclede Christy Clay Products Co., 1711 Ambassador Bldg.; *for mail*, 5938 Cates Ave.
FLAD, Edw. ('91), Cons. Engr., Mem., Miss. River Comm., Rm. 831, U. S. Court House.
FREMON, Edw. B. (J'34), M. E., Ludlow-Saylor Wire Co., 634 S. Newstead Ave.
GARY, Francis P. ('21; '35), Avalon Hotel, 339 N. Taylor Ave.
GAZZAM, Jos. P. ('02), Life Member; 4944 Lindell Blvd.
GLICK, A. Eugene (J'33), 4506 Forest Park Blvd.
GREEN, Fred'k W. ('13), V. P., Charge Opera., St. Louis Southwest. Ry. Lines, 515 Cotton Belt Bldg., 4th & Pine Sts.
GROFF, Wm. C. ('28), Pres., Groff Safety Relay, Inc., 3817 Ashland Ave.
GRUENDLER, Wm. P. ('27; '35), V. P., Gruendler Crusher & Pulverizer Co. 2915 Market St., St. Louis; *for mail*, 512 West Point, University City.
HALL, Clarence ('23; '30), Tool Designer, Century Elec. Co., 1806 Pine St.; *for mail*, 5619 Itaska St.
HAMMERSTEIN, Harold K. ('29; '35), Ch. Engr., Charge Design, Broderick Bascom Rope Co., 4203 N. Union Blvd.
HARRIS, Wm. J., Jr. ('13), Indus. Fuel Engr., Laclede Gas Light Co., 1017 Olive St.
HASSLER, Frank R. ('24; '27; '35), Cons. Engr., 5890 Julian Ave.
HAZARD, Geoffrey C. (J'23), Tech. Dept. Mgr., Socony-Vacuum Oil Co., Inc., 4140 Lindell Blvd.
HEADRICK, H. B. ('30; '35), Field Engr., Serv. Dept., Westinghouse Elec. & Mfg. Co., 717 S. 12th St.
HEINTZE, Arthur L. ('23; '34), Staff Engr., Research & Devel., Sinclair Refining Co., 630—5th Ave., New York, N. Y.; *for mail*, 7445 Teasdale Ave., St. Louis, Mo.
HENNING, H. Clay ('25), Div. Engr., Oper. Sec., St. Louis Water Div., 1640 S. Kingshighway.
HETHERINGTON, Carl F. ('21; '27), Design. Draftsman, Am. Bakers Mchy. Co., 1600 S. Kingshighway; *for mail*, 5643 Bartmer Ave.
HOFFMAN, Geo. A. ('30), Gen. Supt. Pumping Stas., Water Div., 34 E. Grand Ave.
HOWELL, Arthur K. ('12; '21), Pres. & Treas., A. K. Howell Co., 1605 Syndicate Trust Bldg.; *for mail*, 6336 Pershing Ave.
HOYER, Carl O. (J'28), Htg. & Vent. Draftsman, A. H. Vogel, 15th Fl., Chem. Bldg.; *for mail*, 5140 Emma Ave.
IRWIN, Robt. Ray (J'36), Sales Engr., York Ice Mchy. Corp., 117 S. 11th St.

JACKSON, John R. ('15; '22), Engr. of Tests, Mo. Pac. R. R. Co., 3001 Chouteau Ave.
JASCHKA, John H. ('16), Dist. Sales Mgr., Natl. Malleable & Steel Castings Co., 1420 Ambassador Bldg.
JOHNSON, Frank B. ('25), Mech. Expert, Westinghouse Air Brake Co., 1932 N. Broadway.
KAEUFLER, Curt W. V. ('27), Secy., Treas., Sales Mgr., Gen. Engrg. & Mfg. Co., 1523 S. 10th St.; *for mail*, 3512 Victor St.
KELLER, Wm. H. (J'31), Asst. Engr., Pitometer Survey, Water Div., City of St. Louis, 1640 S. Kingshighway; *for mail*, 2249 Klemm Ave.
KELLOGG, Chever McMann ('23; '30; '35), Mfg. Dept., Shell Petroleum Corp., Shell Bldg., St. Louis; *for mail*, 507 W. Pacific St., Webster Groves.
KEY, Fred ('18), V. P., Engr., Charge Design, Key Co., P. O. Box 494, E. St. Louis, Ill.; *home address*, 3535 Hartford St., St. Louis, Mo.
KLINKSIEK, Karl (J'29), Mch. & Tool Designer, 7317 Bruno Ave., Richmond Heights.
KNOLL, Rudolph J. (J'35), Jr. Engr., Design, Lehmann Mch. Co., 3560 Chouteau Ave.; *for mail* 310 Bellerive Blvd.
KOENIG, Lloyd R. ('23; '34), Asst. Prof. M. E., Washington Univ., St. Louis; *for mail*, 412 Fairview Ave., Webster Groves.
KOTHE, Otto W. ('28), Dir. Education, St. Louis Tech. Inst., 4543 Clayton St.
KRAFT, Lester L. ('31), Asst. Mech. Supt., Cahokia Plant, Union Elec. Light & Power Co., 315 N. 12th St.; *for mail*, 4356 Holly Hills.
KUENZEL, Herbert (J'30), 6730 Clayton Ave.
KUMMING, Emil ('21; '35), Charge M. E. Div., Century Elec. Co., 1806 Pine St.
KUPFERLE, Edw. ('99), 4643 Pershing Ave.
KURTH, Carl Hanns ('28), Cons. Engr., Fulton Iron Wks. Co., Delaware St.
LAMACK, August Henry (J'34), 4407 Pennsylvania.
LANGSDORF, A. S. ('20), Dean, Schs. Engrg. & Arch., Wash. Univ.; *for mail*, 5187 Cabanne Ave.
LARKIN, David ('21), Gen. Mgr., Broderick & Bascom Rope Co., 4203 N. Union Blvd.
LEUSSLER, Arthur J. (J'24), Sales Engr., Rhodes Equip. Co., 4485 Olive St.; *for mail*, 5804 Cates Ave.
LOHBILLER, Harry J. ('21) Pres., Am. Power Piping Corp., 706 Security Bldg.
MACNEALE, Neil, Jr. (J'35), Indus. Engr., Procter & Gamble Mfg. Co., E. Grand Ave. & 2nd St.; *for mail*, 4903 Pershing Ave.
MALLINCKRODT, Edw., Jr. (A'18), V. P., Mallinckrodt Chem. Wks., 3600 N. 2nd St.
MARION, Frank I. ('26; '34), Cons. Engr., P. O. Box 485.
MARSHALL, Jay C. (J'29), Plant Engr., Procter & Gamble Mfg. Co., 1232 W. North Ave., Chicago, Ill.; *for mail*, 4635 Bircher Blvd., St. Louis, Mo.
MEINHOLTZ, E. C. (J'32), Mech. Lab. Foreman, Mo. Pac. R. R. Co., 3001 Chouteau Ave.; *for mail*, 4812 Greer Ave.
MENNER, Frederic B. ('19), Office Mgr., Menner & Kimball, 1332 Syndicate Trust Bldg.
MENNINGES, Michael B. ('27), Erecting Engr., Fulton Iron Wks. Co., 825 Wilmington Ave.; *for mail*, 7202a Virginia Ave.
MERKLE, Richard W. (J'24), Secy. to Pres., Union Elec. Light & Power Co., 315 N. 12th Blvd.
MILTENBERGER, Geo. K. ('13; '25), V. P., Charge Opera., Union Elec. Light & Power Co., 315 N. 12th Blvd.
MITCHELL, Harry M. ('23; '25; '35), Pres., Inland Engrg. & Mgmt. Co., 208 N. Broadway; *for mail*, 3816 Dover Pl.
MORSE, Henry S. ('18), Planning Engr., Charge Design, Monsanto Chem. Co., Monsanto, Ill.; *for mail*, 4416 Holly Ave., St. Louis, Mo.
NIEMI, Leonard S. ('29; '35), Test Engr., Union Elec. Light & Power Co., 315 N. 12th Blvd.; *for mail*, 322 N. Boyle Ave.
NOXON, Elmer W. ('28; '35), Mgr. Engrg. Dept., Ralston Purina Co., 8th & Gratiot St.
OHLE, Ernest L. ('06; '08; F'36), Manager, '33-'36, Prof. M. E., Head Dept., Washington Univ.
OONK, Wm. J. (J'22), Dist. Mgr., B. F. Sturtevant Co., 915 Olive St.; *for mail*, 4548 Red Bud Ave.
O'REILLY, Andrew J. ('21), Cons. Engr., Pub. Safety, 2207 S. Grand Blvd.
PAHMEYER, Fred O. ('23), V. P., Heine Boiler Co., 5319 Shreve Ave.
PARMELEY, J. Clyde ('14; '21), Midwest Piping & Supply Co., 1450 S. 2nd St.
PEASE, Robt. M. ('21; '35), Mgr., St. Louis Factory, Axelson Mfg. Co., Ltd., 3844 Walsh St.
PERKINS, Albert T. ('22), Life Member; St. Louis Union Trust Co., Broadway & Locust.
PETERSEN, Sverre ('14), 7241 Maryland Ave.
PICCO, Peter J. (J'31), 1281 Arch Terrace.
RAFTER, Paul T. (J'34), Time Study Dept., Emerson Elec. Co., 2100 Washington Ave.; *for mail*, 3942a Fillmore St.
READ, Leland B. (J'29), Exper. Engr., Carter Carburetor Corp., 2838 N. Spring Ave.
REEVES, Wm. H. ('13), Pres., Reeves & Skinner Mchy. Co., 2211 Olive St.; *for mail*, 4156 Cleveland Ave.
RILLIET, Jean Louis, Jr. ('25), 3952a Sullivan Ave.
RING, Vincent P. ('23; '33; '35), Treas., Knapp-Monarch Co., 3501 Bent Ave.
RODGERS, Wm. M. (J'33), 1388 Belt Ave.
ROSING, Wm. H. V. ('96), Retired.
ROSS, John C. (J'25), Asst. M. E., Hester-Bradley Co.; *for mail*, 1329 Montclair Ave.
ROTTER, Max ('99), V. P., Engrg., Busch-Sulzer Bros.-Diesel Eng. Co., St. Louis, Mo.; *for mail*, 2951 N. Marietta Ave., Milwaukee, Wis.
RULFS, Carl H. ('29), Ch. Draftsman, Power & Plant Design, Union Elec. Light & Power Co., 315 N. 12th St; *for mail*, 1615 Hunter Ave., Richmond Heights.
SAGER, Edwin H. ('23; '35), Instr., M. E. Dept., Washington Univ., Lindell & Skinner Blvds.
SALMON, Jos. H. ('24; '31), Mgr., Shipping & Supplies Div., Shell Petroleum Corp., 600 Shell Bldg.
SCHAEFER, C. T. ('19; '30), Tech. Editor, Automobile Digest, 22 E. 12th St., Cincinnati, Ohio; *for mail*, 5722 Neosho St., St. Louis, Mo.
SCHAINKER, Arnold (J'35), Marketing Engr., Shell Petroleum Corp., 1300 Locust St.; *for mail*, 1118 S. Taylor St.
SCHENCK, Jacob J. (J'36), 5451 Goethe Ave.
SCHILLER, Wm. A. ('20; '35), Indus. Engr., Century Elec. Co., 1806 Pine St.; *for mail*, 6378 Clayton Rd.
SCHLATTER, Rudolf ('10), Engr., Busch-Sulzer Bros.-Diesel Eng. Co., 2nd & Utah Sts.
SCHROEER, Roy A. (J'27), 2007 Alfred Ave.
SCHWARZ, Emil A. (J'34), Asst. Supt., M. E., Charge New Devel., Crunden Martin Mfg. Co., 760 S. 2d St.; *for mail*, 3133 Hawthorne Blvd.
SCHWARZ, Michael ('15; '35), V. P. & Supt., Crunden Martin Mfg. Co., 760 S. 2nd St.; *for mail*, 3133 Hawthorne Blvd.
SEIBEL, Conrad C. ('28), Ch. Engr., Seibel Suessdorf Copper & Iron Mfg. Co., 3802 Hartford St.
SHANKS, Gordon L. ('25), Indus. Engr., Charge Cost Control, Shell Pipe Line Corp., Shell Bldg.
SIEGERIST, Walter ('19; '26), Pres., Medart Co., 3500 De Kalb St., St. Louis; *for mail*, 415 West Point Court, University City.
SIROKY, Edmond ('33), Assoc. Prof. Applied Mechanics, Washington Univ.
SLADE, Frank L. ('23; '24; '35), Sales Engr., Century Elec. Co., 1806 Pine St., St. Louis; *for mail*, 532 Cornelia Ave., Webster Groves.
SPORLEDER, Edmund, Jr. (J'32), Asst. Supt. Plant, Natl. Ammonia Div., E. I. du Pont de Nemours & Co., Foot of Destrehan St.; *for mail*, 4752 Tennessee Ave.
STEWART, Wm. Fraser ('29; '35), Ch. Engr., Fire Prevention & Safety Engrg. Wk., W. H. Markham & Co., 16th Fl., Ry. Exchange Bldg.
STILES, Archie M. ('30), 1640 S. Kingshighway.
STRAUBE, Elmer H. ('32), Ch. Draftsman & Engr., Williams Pat. Crusher & Pulverizer Co., 813 Montgomery St.; *for mail*, 1034 Veronica Ave.
STUEBER, Gustav (J'32), Struc. Engr., Union Elec. Light & Power Co.; *for mail*, 4730 Minnesota Ave.
SYMON, B. G. ('30; '35), Asst. Mgr., Shell Petroleum Corp., St. Louis; *for mail*, 827 Newport Ave., Webster Groves.
TENNEY, Edw. H. ('12), Ch. Engr. Power Plants, Union Elec. Light & Power Co., 315 N. 12th St.
THUMSER, Robt. C. ('19; '29), M. E., Charge Constr. & Maint., Monsanto Chem. Wks., 1700 S. 2nd St.; *for mail*, 3944 Fillmore St.
TOMFORD, Wm. J. (J'29), Application Engr., Hookless Fastener Co., Chicago, Ill.; *for mail*, 5338 Claxton Ave., St. Louis, Mo.
TRABER, Arthur (J'34), 61 Ridgemoor Dr., St. Louis County.
URBAUER, Hugo F. ('23; '35), Chmn. Bd. Dirs., Midwest Piping & Supply Co., Inc., 1450 S. 2nd St.
VAN DEN HEURK, Francis A. ('29; '35), 1st Asst. Engr., M. V. Franklin D. Roosevelt, Federal Barge Line, Foot of N. Market St.; *for mail*, 3620 Utal Pl.
VAN LUIK, Frank W., Jr. ('22; '35), Mech. Pur. Engr., Century Elec. Co., 1827 Pine St., St. Louis; *for mail*, 415 Lee Ave., Webster Groves.
VIGNE, Albert ('31; '35), V. P., Charge Operations, Natl. Bearing Metals Corp., 4930 Manchester Ave.
VON GONTARD, Adalbert ('29; '35), Asst. Gen. Mgr., & Ch. Engr., Anheuser-Busch, Inc., 721 Pestalozzi St.
VON WEHRDEN, F. Walter ('33; '35), Supt., Broderick & Bascom Rope Co., 4233 N. Union Blvd., St. Louis; *for mail*, 8412 Glen Echo Dr., Normandy, St. Louis Co.
WATSON, Raymond H. ('28; '34; '35), Mech. Draftsman, U. S. Engr. Office, U. S. Customs House; *for mail*, 4240A Flad St.
WELLS, Geo. E. ('19), Pres., Geo. E. Wells, Inc., 420 Security Bldg.
WELSH, Robt. W. (J'35), Draftsman, Baumes-McDevitt Co., 1871 Ry. Exch. Bldg.; *for mail*, 2354 Virginia Ave.
WENDT, Leland A. (J'35), Jr. Engr., Shell Petroleum Corp., Roxana, Ill.; *for mail*, 5239 Alcott Ave., St. Louis, Mo.
WILLIAMSON, Gerald V. (J'26), Asst. to Ch. Engr. of Power Plants, Union Elec. Light & Power Co., 315 N. 12th St.
WILMS, Hermann ('14; '21; '35), M. E., Midwest Piping & Supply Co.; for *mail*, 5590 Pershing Ave.
WURDACK, Hugo ('14), Pres., Wurdack Securities Co., 2169 Ry. Exchange Bldg.

SPRINGFIELD

LISTER, Francis G. ('21), Supt. Motive Power, St. Louis-San Francisco Ry.; *for mail*, 615 S. Weller Ave.

SUGAR CREEK, Kansas City Section

LARSON, Godfrey W. (J'29), Designer, Stand. Oil Co. of Ind., Sugar Creek; *for mail*, 6112 S. Benton, Kansas City.
SMITH, Harold A. (J'32), Engr., Charge Utilities, Stand. Oil Co. of Ind.

UNIVERSITY CITY, St. Louis Section

BARNES, Tracy W. (J'36), 6312 Washington Ave.
SCHAUM, Arthur H. ('17), 7350 Shaftesbury Ave.

WEBSTER GROVES, St. Louis Section

HINCHMAN, Geo. N. ('19), 422 Bompart Ave.
SCHWARTZ, Leland P. (J'36), 1015 Grant Rd.

MONTANA

BIG TIMBER

STRICKLAND, Albert W. (A'31), Engr., Charge Design & Constr.

BILLINGS

ANDERSON, Ernest P. (J'36), 522 N. 30th.
EVANS, Geo. A. ('17; '20), M. E., Charge Maint., U. S. Indian Serv., 210 Fratt Bldg.; *for mail*, 217 Lewis Ave.
HIRSCH, Chas. E. (J'23), Dist. Engr., Great West. Sugar Co., P. O. Box 2088.
O'BRIEN, F. R. (J'35), Mech. Draftsman, Constr. Dept., U. S. Indian Serv., 210 Fratt Bldg.; *for mail*, 136 Alderson Ave.
ROESELER, Ernest F. (J'34), Salesman, J. I. Case Co., Billings; *for mail*, Windham.

BONNER

MATSEN, Magnus Melvin (J'36), Dry Kiln Operator, Anaconda Copper Min. Co.; *for mail*, Box 24.

BOZEMAN

CHALLENDER, Ralph T. ('22; '35), Prof., Gen. Engrg., Mont. State College.
THERKELSEN, Eric ('21; '35), Prof. M. E., Chmn. Dept., Mont. State College; *for mail*, 1119 S. 3d Ave.

BUTTE

CRAVEN, Geo. Warren ('29), Cons. Engr., 951 Caledonia St.
GERMAN, Wilbur W. ('33; '35), Utilization Engr., Montana Power Co.; *for mail*, 823 W. Diamond St.
KELLEY, Robt. T. ('29), Asst. M. E., Anaconda Copper Min. Co., 511 Hennessy Bldg.
NORDBERG, C. Victor ('08), Cons. Engr., Nordberg-Rowe Engrg. Co., Rialto Bldg.; *for mail*, 2115 Garrison Ave.
O'BRIEN, Robt. D. (J'35), Asst. Min. Engr., Anaconda Copper Min. Co., Hennessy Bldg.
PARKEN, Edw. A. (J'35), Engr. in Charge, Monarch Mine Syndicate, 1111 S. Arizona St.; *for mail*, 2131 Locust St.
SOLOMON, Edmond J. (J'36), Measurement Clerk, Mont. Power Gas Co., Box 1338.
YOUNG, Paul M. ('29; '35), M. E., Anaconda Copper Min. Co., 511 Hennessy Bldg.; *for mail*, 317 S. Excelsior St.

FORT PECK

ANDREW, M. B. (J'32), Jr. Engr., U. S. Engr. Office; *for mail*, Employees Hotel.
GRIFFITH, Gilbert B. (J'35), Striker (Elec. Dredge Engineman), U. S. Engr. Dept., War Dept., Fort Peck Dam; *for mail*, Block 32.
HENDRICKSON, Ole (J'35), Gen. Steel Foreman, U. S. Engr. Dept., War Dept., Fort Peck Dam; *for mail*, Block 4404.
HINES, John Philip ('23), Box 1223.
HOULD, George F. (J'33), Sr. Draftsman, U. S. Engr. Dept., War Dept., Fort Peck Dam.
SHOOK, Garnett W. (J'35), Subinspector for Corps of Engrs., U. S. A.; *for mail*, Box 1221.

GLASGOW

DYER, Harold F. (J'36), 540—2nd Ave., N.

HARDIN

CAMPBELL, Thos. D. ('14), Pres., Campbell Farming Corp., Hardin, Mont.; *for mail*, 400 Washington Bldg., Los Angeles, Calif.

HELENA

WILLIAMS, Clarence H. (J'36), 1222—9th St.

ROUNDUP

POLICH, Vic. L. (J'35).

NEBRASKA

ALLIANCE, Nebraska Section

JOHNSON, Walter Louis (J'32), 402 Mississippi Ave.

FREMONT, Nebraska Section

SOMMERS, Wm. J. (J'34), 350 W. 15th St.

LINCOLN, Nebraska Section

BARNARD, Niles H. (J'30), Asst. Prof. Mech. Drawing, Univ. of Neb.
BUNTING, Albert ('19), Asst. Prof. Practical Mechanics, Univ. of Neb.
DE BAUFRE, Wm. L. ('09; '13), Chmn., Dept. Engrg. Mechanics, Univ. of Neb.
HANEY, Jiles W. ('14; '21; F'36), Manager, '34-'37; Prof. M. E., Chmn. of Dept., Univ. of Neb.
LEESON, M. Gerald (J'35), Oiler, Mechanic, Beatrice Creamery Co., 720 L St.; *for mail*, 443 S. 12th St.
LUDWICKSON, J. K. (J'33), Graduate Asst. in M. E., Univ. of Neb.; *for mail*, 4722 Hillside.
LUEBS, A. A. ('19; '35), Assoc. Prof. M. E., Univ. of Neb.
MEYER, Allen (J'32), Instrumentman, Dept. of Pub. Wks., State of Neb.; *for mail*, 1414 N. 40th St.
OLSON, Carl J. (J'31), Indus. Gas Engr., Iowa-Neb. Light & Power Co.; *for mail*, 1544 D St.
SJORGREN, C. A. ('23; '35), Asst. Prof. M. E., Univ. of Neb., Sta. A; *for mail*, 201 S. 30th St.
SLAYMAKER, Philip K. ('28), Prof. Mch. Design, Univ. of Neb.; *for mail*, 425 S. 26th St.
WEILAND, Walter F. ('20; '26; '35), Univ. of Neb.
WHITE, Jas. L. ('25; '32; '35), Asst. Engr., Iowa-Neb. Light & Power Co., Gas & Elec. Bldg.

OMAHA, Nebraska Section

BOTTERON, L. K. (J'25), Engineer, Road Tests, Union Pac. R. R., Rm. 504, Union Pac. R. R. Bldg.
BURNETT, J. W. ('34), Gen. Supt. M. P. & M., Union Pac. R. R., 1416 Dodge St.; *for mail*, 117 S. 51st St.
COLSON, J. H. (J'33), Asst. Yard Mgr., Rivett Lumber & Coal Co., 2736 N. 62nd St.; *for mail*, 5640 Corby St.
JABELMANN, Otto ('33), Supt. Shops, Union Pac. R. R.; *for mail*, 4903 Webster St.
LEISEN, Theo. A. ('11), Gen. Mgr., Secy., Metropolitan Utilities Dist., Harney & 18th Sts.
McCAW, Warren W. (J'34), Tech. Foreman, Natl. Park Serv., Levi Carter Park, SP-7; *for mail*, 2018 N. 16th St.
MILES, C. B. ('33), Rep., N. Y. Air Brake Co., Hotel Fontenelle; *for mail*, 2965 Harney St.
MOULTON, Clarence F. ('26; '33; '35), Asst. Oper. Engr., Neb. Power Co., 4th & Jones Sts.; *for mail*, 1901 Happy Hollow Blvd.
PROHASKA, R. J. (J'31), Engr., Neb. Bur. Roads & Bridges, State Capitol, Lincoln; *for mail*, 2210 S. 14th St.
ROESKY, R. Henry ('30), Mech. Inspr., Neb. Power Co.; *for mail*, 2241 Larimore Ave.
ROGERS, Geo. Arthur (J'34), Asst. Mgr., Dealer Line Dept., Fairbanks, Morse & Co.; *for mail*, 356 N. 40th St.
RUF, Lee J. ('27), Supt. Power Plant, Neb. Power Co., 4th & Jones St.; *for mail*, 120 W. Pacific St.
SAYLES, Maynard A. (J'34), Asst. Plant Supt., Bemis Bros. Bag Co., 614 S. 11th St.

PENDER, Nebraska Section

POSPISIL, Philip J. (J'35).

PLATTSMOUTH, Nebraska Section

MANN, Robt. M. (J'36), 418 Ave. A.

NEVADA

BOULDER CITY

BERKLEY, H. Walter ('29), Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.; *for mail*, Box JJ.

CARSON CITY

BURNER, Gordon (J'32), Asst. Engr., Bridge Dept., Nev. State Highway Dept., Carson City; *for mail*, Yerington.
CURRIE, Frank J. (J'36), c/o Highway Dept.

GOLDPOINT

DIECKMANN, Otto A. (J'31).

McGILL

SAGER, Norbert W. ('27; '33; '35), Asst. Ch. Engr., Power Plant, Nev. Consltd. Copper Co.; *for mail*, Box 998.

RENO

GALLAWAY, Howard M. (J'35), 1047 W. 2nd St.
PARMENTER, L. E. (J'35), Draftsman, State Highway Dept., Carson City; *for mail*, 635 S. Center St., Reno.
SIBLEY, F. H. ('08), Dean, College of Engrg., Univ. of Nev.

ROUND MOUNTAIN

MICHAL, Edwin B. (J'34), Draftsman, A. O. Smith Corp.; *for mail*, Round Mountain.

TONOPAH

HORSCHMAN, Robt. Lowell (J'35), Elec., Gen. Metals Recovery Corp., Millers; *for mail*, Box 761, Tonopah.

NEW HAMPSHIRE

ACWORTH, Green Mountain Section

SLADER, Walter ('15), Tech. Writer.

ANDOVER

FISHER, V. Hoitt (J'32).

BERLIN

KELLEY, F. W., Jr. (J'29), 256 Main St.
MEGLITZ, Wm. B. ('26; '35), Ch. Engr., Mech. Div., Brown Co.
SCHUR, Milton O. ('28), Research Engr., Brown Co.; *for mail*, 300 Church St.
WARDWELL, Harry J. (J'30), Mech. Draftsman, Brown Co.; *for mail*, 140 Maple St.

CLAREMONT, Green Mountain Section

HILLARD, Alton M. (J'33), 86 Chestnut St.

CONCORD

JACKSON, Henry D. ('12), 29 Noyes St.

DURHAM

DONOVAN, Edw. T. (J'21), Asst. Prof. M. E., Univ. of N. H.
GETCHELL, Edw. L. ('20; '35), Assoc. Prof. M. E., Univ. of N. H.
LATON, Thos. J. ('08; '21; '35), Asst. Prof. M. E., Univ. of N. H., Durham; *for mail*, Madbury.
MAURICETTE, Robt. E. (J'33), Grad. Asst., Univ. of N. H., Durham; *for mail*, 950 Central Ave., Dover.
UICKER, John J. (J'32), Instr. M. E., Univ. of N. H.

EXETER

FRENCH, Kent A. (J'34), 34 Washington St.

FRANKLIN

SUROWIEC, Edw. J. (J'34), 29 W. Bow St.

GOSHEN

PIKE, John G., Jr. (J'33).

HAMPTON

TRUE, Russell M. (J'29), Box 141.

HANOVER, Green Mountain Section

HICKS, Jas. R. (J'32), Asst. Prof. Power & Engrg., Thayer School of Civil Engrg., Dartmouth College, Hanover.
MOORE, Wm. Henry ('28), Ch. Engr., Dartmouth College; *for mail*, 29 S. Park St.

KEENE

WALLACE, Russell G. (J'29), 242 Beaver St.

LAKEPORT

WOOLDRIDGE, Wilber W. ('32), Box 12.

LEBANON, Green Mountain Section

GARRETT, Eric H. ('27), Mgr., Kendrick & Davis Co., 12 Water St.

LISBON

EBERHARDT, John D. ('26), Supt. Car Dept., Theo. Schwamb Co., 1171 Massachusetts Ave., Arlington, Mass.; *for mail*, c/o Hotel Moulton, Lisbon, N. H.

LITTLETON

YOUNG, Riley T. ('23), Engr., 22 Maple St.

MANCHESTER

HUNT, Saml. P. ('25), Life Member; Cons. E. & M. Engr., 852 Elm St.; *for mail*, 263 N. Bay St.
MACEK, Francis Jas. (J'34), Recorder for Topography Party, U. S. Engr. Dept., Custom House, Boston, Mass.; *for mail*, 20 Birch St., Manchester, N. H.
MORIN, Romeo P. (J'34), 440 Coolidge Ave.
O'MALLEY, Wm. J. (J'35), 248 Green St.
PARK, Carl Palmer ('30), Ch. Engr., U. S. Bobbin & Shuttle Co., Mast St.

NASHUA

BRODERICK, Robt. E. (J'28), Mgr., Door Factory, Johns-Manville Corp.

NEWPORT

JOY, Frank A. (J'30), Engr., N. H. Power Co.; *for mail*, 146 Laurel St.

PENACOCK

BARNETT, G. Morrill (J'34), Research Worker, N. H. State Planning & Devel. Comm., Concord; *for mail*, 6 Washington St., Penacock.

PLYMOUTH

WORTHEN, John H. (J'33), 71 Langdon St.

PORTSMOUTH

DOWNING, Harry F. ('19; '35), Assoc. M. E., Navy Yard; *for mail*, 135 Thaxter Rd.
TILTON, Henry B. ('17), V. P., Gen. Mgr., Morley Button Mfg. Co., Islington St.; *for mail*, 1229 South St.

SOMERSWORTH

JACKSON, H. Olin ('23; '24), Treas. & Gen. Mgr., Great Falls Bleachery & Dye Wks., Inc.; *for mail*, 39 Page St.

SUNCOOK

CHASE, Erwin A. (J'31), Suncook Mills Co.; *for mail*, Maple St.

WILTON

ABBOTT, Wm. G., Jr. ('19; '35), Gen. Mgr., Abbott Mch. Co.

NEW JERSEY

ALDENE, Plainfield Section

DAVIS, Frank Lawrence ('30), Devel. Engr., Hyd. Mchy., Watson-Stillman Co., Aldene; *for mail*, Box 7, Kenilworth.
STILLMAN, A. F. ('07; '12), Dir., Watson Stillman Co., Aldene N. J.; *for mail*, 5 Red Oak Rd., Bronxville, N. Y.

AMPERE, Metropolitan Section

BEUTLER, Albert J. (J'29), Draftsman, Wired Radio, Inc., 4th Ave., Ampere; *for mail*, 61 Claremont Ave., Jersey City.
WARING, Edw. H. ('13), Gen. Engr., Crocker Wheeler Elec. Mfg. Co.

ANDOVER, Metropolitan Section

HORTON, Ralph D. (J'27).

ARLINGTON, Metropolitan Section

ADLER, Alphonse A. ('07; '12), Cons. Engr., 85 Stewart Ave.
FLEMING, Wills M. ('05; '09), Engr., Charge Design Reciprocating Pumps, Worthington Pump & Mchy. Corp., Worthington Ave., Harrison; *for mail*, 40 Clinton Ave., Arlington.
LAWSON, Wm. O. ('22; '35), Plant Engr., Plastics Dept., E. I. du Pont de Nemours & Co., 626 Schuyler Ave.
MARSHALL, Jas. West ('23; '31; '35), 165 Seeley Ave.
McILHENNEY, Wm. ('13), Project Engr., E. I. du Pont de Nemours & Co., 626 Schuyler Ave.; *for mail*, 155 Linden Ave.
ZELIFF, David E. (J'35), 21 Quincy Ave.

ASBURY PARK, Metropolitan Section

ALDEN, John D. ('12), Gas Engr., Jersey Cent. Power & Light Co., Grand Ave.; *for mail*, 1219—5th Ave.
BANCE, E. S. (J'34), Asst. Engr., Gas Dept., Jersey Cent. Power & Light Co., 501 Grand Ave.

MERTENS, Fred M. (J'34), 509—6th Ave.
ROOME, Geo. R. S. (J'27), M. E., Charge Maint., Raritan River Plant, Sayreville, of Jersey Cent. Power & Light Co., 501 Grand Ave., Asbury Park; *for mail,* 138 South St., Freehold, N. J.
VREELAND, Milton A. ('35), Ch. System Oper., Jersey Cent. Power & Light Co., 501 Grand Ave., Asbury Park; *for mail,* Woodbine Ave., Little Silver.
WILCOX, Donald B. (J'34), Mgr., C. G. Winans Co., P. O. Box 124; *for mail,* 611 Munroe Ave.

ATLANTIC CITY, Philadelphia Section

ARMSTRONG, E. R. ('16), Hotel Claridge.
CARSE, David B. ('89), 14 S. Lancaster Ave., Margate.
LEDSHAM, W. H. ('35), Ch. Engr., Charge Maint. & Power, Leeds & Lippincott Co., Chalfonte-Haddon Hall.
NEWBOLD, Richard S. ('20), 3300 Pacific Ave.
PURINTON, Arthur J. ('93), V. P., Gen. Mgr., Atlantic City & Shore R. R. Co., Maine & Caspian Aves.
STROUSE, Bernard H. (J'30), Asst. Engr., Sidney B. Strouse & Warren Webster & Co., 429 Guarantee Trust Bldg.; *for mail,* 22 S. Illinois Ave.
STROUSE, Sidney B. ('09; '18; '35), Cons. Engr., 500-529 Guarantee Trust Bldg.

ATLANTIC HIGHLANDS, Metropolitan Section

SCHAPHORST, Wm. F. ('13; '21), Cons. M. E., Rm. 210, 45 Academy St., Newark; *home address,* 160 Wesley Ave., Atlantic Highlands.

AUDUBON, Philadelphia Section

MANGOLD, Carl P. (J'36), 202 Davis Ave.
MONTAGUE, Jos. F. ('21; '35), Gen. Mgr., Camden-Serv. Stas., Inc., R. F. D. 1, Sewell; *for mail,* 22 Payson Ave., Audubon.
PRICHARD, Walter J. (J'35), 120 W. Atlantic Ave.

AVENEL, Metropolitan Section

RICHARDS, Walter E. (J'35), M. E., Barber Asphalt Co., Maurer; *for mail,* 17—5th Ave., Avenel.

BAY HEAD, Metropolitan Section

ELMER, Wm. ('96; '13), Manager, '25-'28; Vice-President, '28-'30; Retired Asst. Engr., Pa. R. R., Philadelphia, Pa.; *for mail,* 32 North St., Bay Head, N. J.

BAYONNE, Metropolitan Section

ALTIERI, Nicholas Louis (J'36), Gould & Eberhardt, Irvington; *for mail,* 952 Broadway, Bayonne.
BENZIEN, Fritz (J'30), Engr., Charge Design, Tide Water Oil Co., 22nd St.; *for mail,* 145 Newman Ave.
BUDDINE, Norman T. (J'28), Engr., Tide Water Oil Co., E. 22nd St.
CROSBY, Geo. Fred., Jr. (J'34), M. E., Charge Design & Maint., Internatl. Nickel Co., Research Lab., Oak St.
FRANKENFIELD, C. Walter (J'34), Research Asst., Motor Lab., Tide Water Oil Co.; *for mail,* 259 Ave. E.
FROHLIN, John ('27; '35), Supt., Bergen Point Iron Wks.; *for mail,* 100 Humphrey Ave.
GAST, Geo. F. ('10; '21), Mech. Supt., Tide Water Oil Co., Bayonne; *for mail,* 9 Van Houten Ave., Jersey City.
HEIMBERGER, Geo. J. ('22), Asst. Ch., Proposition Dept., Babcock & Wilcox Co., Lexington Ave. & 3rd St.; *for mail,* 46 Ave. B.
HOFFMAN, Raymond S. ('22), Mech. Supt., Stand. Oil Co. of N. J., Bayonne; *for mail,* 218 Sinclair Pl., Westfield.
HOLDING, J. Brewster (J'33), 48 W. 38th St.
JOHNSON, Joel M. ('29; '35), Engr., Power Dept., Stand. Oil Co. of N. J.; *for mail,* 47 Ave. B.
KROL, Peter F. (J'33), M. E. Charge Inspc., Tide Water Oil Co., 22nd St., Bayonne; *for mail,* 726 S. 19th St., Newark.
KURILLA, John (J'29), Test Engr., Babcock & Wilcox Co.; *for mail,* 40 E. 28th St.
LANDFEAR, Geo. H. ('17; '35), Checker, M. E. Dept., N. Y. Edison Co., Inc., 4 Irving Pl., New York, N. Y.; *for mail,* 48 E. 40th St., Bayonne, N. J.
MACK, John J., Jr. ('26; '32; '35), Design Supt., Tide Water Oil Co.; *for mail,* 100 W. 33rd St.
McINTYRE, Malcolm ('18), V. P., Bergen Point Iron Wks., Bayonne, N. J.; *for mail,* Riverside, Conn.
NIGH, Geo. W. ('14; '25), 19 W. 45th St.
PRENTICE, John ('13), Supt., Babcock & Wilcox Co., Lexington Ave. & 3rd St.; *for mail,* 83 Broadway.
SEARL, John (J'36), Tide Water Oil Co., Bayonne, N. J.; *for mail,* 93 Rose Ave., New Dorp, S. I., N. Y.
STURM, Geo. Wm. (J'33), Ch. Draftsman (Electrical), United Shipbldg. & Dry Dock Co., Mariners Harbor, S. I., N. Y.; *for mail,* 30 W. 45th St., Bayonne, N. J.
VERNON, Clinton M. (J'26), Asst. Supvr. Power, Bayonne Refinery, Stand. Oil Co. of N. J.
WERNER, Philip (J'32), Designer & Asst. to M. E., Charge Maint., Internatl. Nickel Co., Oak St.

BEDMINSTER, Metropolitan Section

BEEKMAN, Henry M. ('17; '24; '32).

BELLEVILLE, Metropolitan Section

HOLLAND, Fred'k W. ('21; '35), M. E., Design, Constr. & Maint., Postal Tel. Cable Co., 67 Broad St., New York, N. Y.; *for mail,* 176 DeWitt Ave., Belleville, N. J.
JOHNSON, Jas. F. ('35; '35), Comb. Engr., Indus. Power Rep., Pub. Serv. Elec. & Gas Co., Room 3104, 80 Park Pl., Newark; *home address,* 4 Belmohr St., Belleville.
KREGAR, Scott W. (J'35), Engr., Prod. Dept., Natl. Grain Yeast Corp., Mill St., Belleville; *for mail,* 225 Orton Rd., Caldwell.
OGUR, E. ('29; '35), Cons. M. & E. E., 38 Crescent Terrace.

BELMAR, Metropolitan Section

BETTS, Col. Philander ('12), Life Member; 100—10th Ave.

BERGENFIELD, Metropolitan Section

KETCHPEL, Paul A. ('36), Devel. Engr., Stand. Stoker Co., Inc., 350 Madison Ave., New York, N. Y.; *home address,* 40 Brook St., Bergenfield, N. J.

BEVERLY, Philadelphia Section

RILEY, Wm. L. ('30), M. M., U. S. Mar. Corps, 1100 S. Broad St., Philadelphia, Pa.; *for mail,* 426 Manor Rd., Beverly, N. J.

BLOOMFIELD, Metropolitan Section

BAYLIS, Robt. N. ('92), Pres., Baylis Co. & Smokador Mfg. Co., Inc., 52 Nelson St.
CLAUSS, Chas. A. (J'25), Engr., Charge Design, Baylis Co., 50 Nelson St.; *for mail,* 200 Franklin St.
DE LA TORRE, Luis Garcia (J'34), 73 Berkeley Ave.
DUNNICAN, Geo. W. ('30; '35), Ch. Engr., Design, Maint. & Prod., Lehn & Fink, Inc., 194 Bloomfield Ave.; *for mail,* 838 Broad St.
EHRKE, Louis F. (J'24), Research Engr., Westinghouse Lamp Co.
FLEISCHMANN, Walter L. (J'35), Indus. Control Dept., Gen. Elec. Co., 5 Lawrence St.
GESELL, Wm. H. ('18; '21; '35), V. P., Lehn & Fink, Inc., 192 Bloomfield Ave.
GETZOFF, Edw. M. ('19; '25; '30), Designer, Exper. Dept., Westinghouse Lamp Co., Bloomfield; *for mail,* 1045 North Ave., Elizabeth.
GIBBONS, Jas. O. G. ('14; '19), Cons. Engr., 169 Bloomfield Ave.
HAMMOND, Edgar S. ('28), Pres., Charge Sales, E. S. Hammond, Inc., 169 Bloomfield Ave.; *for mail,* 42 Hill St.
KAUFMAN, Milton (J'34), 132 Washington St.
KELSEY, Harold D. ('30), Engr., Charge Design, Gen. Elec. Co., 5 Lawrence St.
LELEK, Thaddeus A. (J'34), Draftsman, Tank Design, Breeze Corps., Inc., 28 S. 6th St., Newark; *for mail,* 45 Mill St., Bloomfield.
LOHSE, Fred'k E. ('31; '35), M. E., Charge Maint. & Design, Clark Thread Co., Lakewood Terrace.
REILLY, Thos. J. (J'34), Asst. to Supvr., Jenkins Mfg. Co., Bloomfield, N. J.; *for mail,* 3228 Decatur Ave., New York, N. Y.
ROBINSON, Manuel G. ('25; '35), Devel. Engr., Gen. Elec. Co., 5 Lawrence St., Bloomfield; *for mail,* 63 Midland Ave., Glen Ridge.
SCHAUFFLER, David J. (J'34), 55 Park Ave.
SPOFFORD, Warren A. (J'30), Air Conditioning Dept., Design Engrg. Div., Gen. Elec. Co.
TEAGUE, Hubert Melvin ('25; '27; '35), 42 Park Ave.
WELLER, Frank E. ('25; '35), 531 Beardsley Ave.
WERRY, John A. (J'34), Mch. Designer, Walter Kidde & Co., Inc., 60 West St.; *for mail,* 130 Franklin St.
WESTERDAHL, A. ('27), Design & Project, W. Va. Pulp & Paper Co., 230 Park Ave., New York, N. Y.; *for mail,* 57 Woodland Rd., Bloomfield, N. J.
WILKS, August ('25; '35), Wks. Mgr., Walter Kidde & Co., Inc., 60 West St.; *for mail,* 153 Franklin St.
WOOLSON, Clifford G. ('16), 48 Hill St.

BOGOTA, Metropolitan Section

ABBOTT, James, Jr. (J'21), Mem. Tech. Staff, Bell Tel. Labs., Inc., New York, N. Y.; *for mail,* 466 Larch Ave., Bogota, N. J.
BOWERS, Jas. H. ('33; '35), Ch. Engr., Bogota Paper & Board Corp., Bogota; *for mail,* P. O. Box 133, Clifton.
LEFREN, Karl A. ('15; '20), Karl A. Lefren, Inc., 32 River Rd.
McGUIRE, F., Jr. (J'33), 67 Walnut Ave.

BOONTON, Metropolitan Section

HOWELL, Francis K. ('26), Engr., Charge Dryer Sales, Buell Engrg. Co., 70 Pine St., New York, N. Y.; *home address,* 121 Schultz St., Boonton, N. J.
KOCHER, Edw. H. ('30), Pres. & Gen. Mgr., Bijur Lub. Corp., 43-01—22nd St., Long Island City, N. Y.; *for mail,* Reserve St., Boonton, N. J.

BORDENTOWN, Philadelphia Section

LONDAHL, Edwin L. (J'35), Asst. Shop Foreman, Geo. W. Swift & Co., Bordentown; *for mail,* 336 Gardner Ave., Trenton.

BOUND BROOK, Plainfield Section

AUSTIN, Richard S. ('16; '21; '31), Maint. & Constr. Mgr., Calco Chem. Co., Inc., Bound Brook; *for mail,* 651 Shadowlawn Dr., Westfield.
BEAN, C. H. ('15), Mgr., Power Dept., Calco Chem. Co., Inc.; *for mail,* 410 Church St.
BIGELOW, Carle M. ('17; '18; '21), Dir., Pharmaceutical Div., Calco Chem. Co., Inc., Turnpike Rd.
DIDRIKSEN, Herluff ('26; '33; '35), M. E., Design, Gen. Aniline Wks., Inc., Grasselli; *for mail,* N. Mountain Ave., Bound Brook.
HEINZ, W. B. (J'30), Engrg. Dept., Calco Chem. Co., Inc.
JEFFCOTT, Robt. C. ('12), Pres., Calco Chem. Co., Inc.
McMURRAY, John H. ('17; '26), Asst. Gen. Mgr., Calco Chem. Co., Inc.; *for mail,* N. Mountain Ave.
ROHRHURST, Wm. ('27; '34; '35), Supt. of Power, Calco Chem. Co., Inc.; *for mail,* 537 Watchung Rd.
TAYLOR, Roy M. (A'22), V. P., Charge Opera., Calco Chem. Co., Inc.
WILLIS, Chas. C. ('20), Cons. Engr., P. O. Box 307, Cedar Crest, Bound Brook.

BRIDGETON, Philadelphia Section

LUCAS, Clarence W. ('17), Die Engr., Ferracute Mch. Co.; *for mail,* 233 W. Commerce St.
SMITH, Percival H. (A'22), Ferracute Mch. Co.; *for mail,* P. O. Box 354.

BURLINGTON, Philadelphia Section

ABERCROMBIE, W. Taylor, Jr. ('21; '25; '35), M. E., U. S. Pipe & Fdy. Co., Burlington; *for mail,* 546 Farnum St., Beverly.
CONARD, Wm. R. (A'06), Professional Engr., 321 High St.
HUSSEY, Elliot A. (J'29), Test Engr., Pub. Serv. Elec. & Gas Co.
KARG, Wm. E. (J'24), Test Engr., Generating Sta., Pub. Serv. Elec. & Gas Co.

BUTLER, Metropolitan Section

MULLEE, Wm. R. (J'23), Supvr., Stands. Dept., Am. Hard Rubber Co.
SHEREFF, Bernard (J'30), Engr., Stands. Dept., Am. Hard Rubber Co.
STOECKER, Otto C. ('21; '35), Asst. Master Mechanic, Am. Hard Rubber Co., Butler; *for mail,* 408 Colfax Ave., Pompton Lakes.
STRACHAN, Geo. C. (J'21), Indus. Engr., Am. Hard Rubber Co.
VAIL, John J., Jr. (J'35), Prod. Dept., Am. Hard Rubber Co., Butler; *for mail,* 278 W. Emerson Ave., Rahway.

CALDWELL, Metropolitan Section

BROAS, R. F. (J'34), 6 Welshman Court.
GALUSHA, Albert L. ('18), Ch. Engr., Gas Producer Dept., Dover Boiler Wks., 50 Church St., New York, N. Y.; *for mail,* 35 Hillcrest Rd., Caldwell, N. J.
MACLEHOSE, Maitland ('27; '35), Engr., Berwind White Coal Mining Co., 1 Broadway; *for mail,* 72 Forrest Ave.
STEWART, Nelson H. (J'26), Asst. Div. Engr., Westinghouse Lamp Co., Bloomfield; *for mail,* 62 Smull Ave., Caldwell.

CAMDEN, Philadelphia Section

ABEL, Clarence R. ('26; '35), Supt. Elec. Dept., Am. Brown Boveri Elec. Corp., Camden; *for mail,* 111 Avondale Ave., Haddonfield.
BLAIR, J. Arthur ('21; '26), Asst. Ch. Engr., Campbell Soup Co., 2nd & Market Sts., Camden; *for mail,* 245 Rhoads Ave., Haddonfield.
BROUSSEAU, Edw. W. ('20; '25; '35), Installation & Serv. Div., RCA Mfg. Co., Inc., Camden, N. J.; *for mail,* D-22, Chestnut Hill Apts., Evergreen & Crefeld Sts., Chestnut Hill, Philadelphia, Pa.
FREY, Albert C. (J'30), Specification Engr., Radio Condenser Co., Thorne & Copewood Sts., Camden; *for mail,* 139 Reading Ave., Barrington.

HARBESON, Jas. P., Jr. ('18; '35), M. E., Charge Plant, Camden Forge Co.
HORNBERGER, Fredk. C. (J'36), Plant Engr., F. A. Vieser & Son, Inc., Camden, N. J.; *for mail*, 232 S. 44th St., Philadelphia, Pa.
JORGENSEN, Wm. ('22), Am. Brown Boveri Elec. Corp.
LAWRENCE, Kenneth C. (J'34), 715 Cooper St.
LOFFT, W. A. ('32), Ch. Engr., Power & Maint., Eavenson & Levering Co., 3d & Jackson Sts. Camden; *for mail*, 515 Bettlewood Ave., Collingswood.
MARSHALL, Harold F. ('17; '23; '35), Asst. Sales Mgr. & Adv. Mgr., Warren Webster & Co. 17th & Federal Sts., Camden; *for mail*, 103 Morgan Ave., Palmyra.
MIDDLETON, Albert C. (A'11), Retired; 606 Wilson Bldg.
REID, Jas. W., Jr. (J'35), Spec. Machinist, N. Y. Shipbldg. Corp., Broadway; *for mail*, 514 Rex Pl.
ROHLIN, Karl W. ('22; '31; '35), Head Moderator Engrg. Dept., Warren Webster & Co., 17th & Federal Sts., Camden; *for mail*, 4453 Terrace Ave., Merchantville.
SCOTT, Edgar G. ('13), Ch. Engr., Campbell Soup Co., 2nd & Market Sts., Camden; *for mail*, 18 Colonial Ave., Moorestown.
SHEA, Albert L. ('29; '35; '35), Indus. Engr., Campbell Soup Co., 2nd & Market Sts.
STEWART, Jas. G. ('23; '35), Asst. M. E. MacAndrews & Forbes Co., 3d & Jefferson Sts.
TEAF, John H. ('25; '32; '35), Engr., Charge Design, RCA Mfg. Co., Inc., Camden; *for mail*, 97 Kendall Blvd., Oaklyn.
WEBSTER, Warren (A'03), Pres., Warren Webster & Co., 17th & Federal Sts.

CARTERET, Plainfield Section

BOWER, Harold W. (J'31), U. S. Metals Refining Co., Carteret; *for mail*, 76 Elm Ave., Rahway.
EVERETT, Russell W. (J'18), Engr., Foster Wheeler Corp., Carteret; *for mail*, 56 Lincoln Ave., W., Roselle Park.
HILBERT, Wm. M. ('31), Ch. Draftsman, U. S. Metals Refining Co., Carteret; *for mail*, 19 W. Stearns St.
WEXLER, Meyer (J'30), 34 Railroad Ave.

CHATHAM, Metropolitan Section

WHITE, Louis R. ('36).

CLIFFSIDE PARK, Metropolitan Section

BENDA, Harry R. ('14; '31), V. P., Ch. Engr. P. Pryibil Mch. Co., Inc., 41-31 Vernon Ave. Long Island City, N. Y.; *for mail*, 250 Clark Terrace, Cliffside Park, N. J.
VOSS, Wilbur F. (J'35), 253 Morningside Ave.

CLIFTON, Metropolitan Section

BABEOR, Jos. A. (J'36), 300 Burgess Pl.
BUFFONE, Jos. J. (J'35), Hull Struc. Draftsman Gibbs & Cox, Inc., 21 West St., New York. N. Y.; *for mail*, 799 Main Ave., Clifton, N. J.
DECKER, Clayton A. ('30; '35), Sales Engr. SKF Industries, Inc., Front St. & Erie Ave., Philadelphia, Pa.; *for mail*, 222 Harding Ave., Clifton, N. J.
DOBSON, John G. (J'36), Devel. Engr., Wallace & Tiernan, Inc., Mill & Main Sts., Belleville; *for mail*, 494 Dwas Line Rd., Clifton.
KLEINSCHMIDT, Kenneth (J'35), Draftsman, Manhattan Rubber Mfg. Co., Passaic; *for mail* 38 DeMott Ave., Clifton.
KUEHN, Kurt Frank (J'32), 148 Clifton Ave.
TEN EYCK, H. R. ('24; '27; '35), Owner. Ten Eyck Transit, 163 Washington Ave.

CLOSTER, Metropolitan Section

BROWN, Wm. N. ('31), Sales Engr., Parry Engrg. Co., 154 Nassau St., New York; *for mail* Box 252, Piermont Rd., Closter, N. J.

COLLINGSWOOD, Philadelphia Section

DECKER, Jacob ('27; '35), Indus. Engr., 17 E. Palmer Ave.

COYTESVILLE, Metropolitan Section

SIKOSEK, Ferdinand J. (J'33), Sales Correspondent, Consltd. Ashcroft-Hancock Co., Inc., 65th Fl. Chrysler Bldg., New York, N. Y.; *home address*, 2463—1st St., Coytesville, N. J.

CRANBURY, Metropolitan Section

STULTS, Wallace W. (J'33), R. D. 3.

CRANFORD, Plainfield Section

BATES, Geo. H. ('14), V. P., Charge Opera., & Comptroller, United Shipyards, Inc., 11 Broadway, New York, N. Y.; *for mail*, 18 Hampton St., Cranford, N. J.
BRONDUM, Paul V. (J'27), Designing Engr., West. Elec. Co., Inc., 100 Central Ave., Kearny; *for mail*, 348 S. Union Ave., Cranford.
LEAVITT, Geo. Edw., Jr. ('27), Plant Engr., Charge Const., Maint. & Opera., So. Cotton Oil Co., 160 E. 22nd St., Bayonne; *for mail*, 607 Springfield Ave., Cranford.
LEET, Leslie N. ('29), Pres., Mgr., Leet Organ Co., Inc., 22 South Ave., W.
MESSINGER, J. P. (J'21), Engr., Fuel Oil & Burner Sales, Stand. Oil Co. of N. J., 26 Broadway, New York, N. Y.; *home address* 24 Springfield Ave., Cranford, N. J.
ROGERS, R. E., Jr. (J'29), Sales Engr., Foxboro Co., 420 Lexington Ave., New York, N. Y.; *home address*, 20 W. Holly St., Cranford, N. J.

DELAWANNA, Metropolitan Section

LECLERCQ, L. E. (J'34), 348 Delawanna Ave.

DOVER, Metropolitan Section

DILL, Arthur H. ('28), Ord. Engr., Ch. of Inspec., Picatinny Arsenal; *for mail*, Elycroft Terrace.
LUKENS, Wm. L. ('17; '21), R. D. 1.
ROGERS, Gilbert E. ('23; '35), Assoc. Ord. Engr., Ord. Dept., U. S. A., Picatinny Arsenal.

DUMONT, Metropolitan Section

SUTHERLAND, Wm. E. (J'36), 53 Thompson St.

DUNELLEN, Plainfield Section

FABER, JOHN P. ('08; '17), Ch. Engr., Transit Mixers, Inc.; *for mail*, 205 N. Washington Ave.
HANSEL, Henry (J'33), 447 Prospect Ave.

EAST MILLSTONE

WARDEN, Howard C. (J'36), Market St.

EAST ORANGE, Metropolitan Section

APPS, Chas. H. ('99), Estimating Engr., Am. Loco. Co., 30 Church St., New York, N. Y.; *home address*, 46 Lenox Ave., E. Orange, N. J.
BAILY, Theo. O. (J'36), 164 Oraton Pkwy.
BATO, Andrew A. ('24; '27), Cons. Engr., 227 Park Ave.
BERGMANN, Charles R. (J'35), 166 N. 17th St.
BIRD, Stanley P. (J'34), Draftsman, Breeze Corp. 6th St., Newark; *for mail*, 90 N. 23rd St., E Orange.
BOYNTON, Earl S. ('20; '35), 31 Madison Ave.
BROOME, Ernest L. ('98; '09), Engr., Estimating Dept., M. W. Kellogg Co., Jersey City; *for mail*, 15 Summit St., E. Orange.
BROWN, Geoffrey C. ('19; '22), Cons. Engr., 72 Harrison St.
CAREY, Francis E. (J'32), Asst. Research Engr., Storage Battery Div., Thomas A. Edison, Inc., 51 Lakeside Ave., W. Orange; *for mail*, 540 Park Ave., E. Orange.
DAVENPORT, Granger ('25; '32; '35), Research Engr., Gould & Eberhardt, 480 Chancellor Ave., Irvington; *for mail*, 17 Summit St., E. Orange.
DURLAND, Wm. P. (J'31), Gen. Purchasing Dept. Worthington Pump & Machy. Corp., Worthington Ave., Harrison; *for mail*, 44 Hawthorne Ave., E. Orange.
EWER, Roland G. ('19), Ch. Engr., Carbondale Mch. Co., 401 Worthington Ave., Harrison; *for mail*, 115 S. Clinton St., E. Orange.
FINIGAN, Robt. J. (J'34), 80 Eppirt St.
FREIDAY, Jay A. ('20), V. P., Ch. Engr., Thos. E Murray, Inc., 114 Liberty St., New York. N. Y.; *home address*, 35 Cleveland Terrace E. Orange, N. J.
GALLOWAY, Wm. C. (J'29), Draftsman, Works Progress Admin., City Hall, Newark; *for mail* 18 Summit St., E. Orange.
GOEGL, Ludwig J. (J'24), 215 Park Ave.
HENDERSON, Robt. H. ('07), Propr., Henderson Elec. Co., Ampere; *for mail*, 181 Greenwood Ave., E. Orange.
HIRSCH, Sylvan R. (J'28), Asst. Ch. Engr., Carbondale Mch. Corp., Worthington Ave., Harrison; *home address*, 112 N. Walnut St., E. Orange.
HUBBARD, Albert B. (J'28), 179 Brighton Ave.
HURLBURT, W. F., Jr. (J'35), 64 Greenwood Ave.
KIDD, Geo. F. ('15), M. E., 61 Hollywood Ave.
LANSING, Raymond P. ('17; '26), V. P., Eclipse Aviation Corp., 545 N. Arlington Ave.
LAZEAR, Weston B. ('15; '19), 82 Chestnut St.
LIBBY, Samuel H. ('97; '00), Retired; 23 Whittlesey Ave.
MacGRATH, Kenneth ('27; '35), Factory Mgr. Eclipse Aviation Corp., 545 N. Arlington Ave.
MARSHALL, John T. (J'30), Eclipse Aviation Corp.
MARTIN, Chas. H. (J'33), 303 N. Grove St.
MITCHELL, Chas. T. ('29), Apt. 307, 18 Summit St.
NARDONE, Romeo M. ('34; '35), Devel. Engr., Eclipse Aviation Corp.; *for mail*, 76 Washington St.
NORDT, Paul W., Jr. (J'35), Indus. Engr., Charge Prod., Automatic Switch Co., 154 Grand St. New York, N. Y.; *for mail*, 12 N. 20th St., E. Orange, N. J.
PANSEGRAU, Carl (J'35), 490 N. Grove St.
PIERCE, Arnold C. (J'36), Engr., Metro. Life Ins. Co., 1 Madison Ave., New York, N. Y.; *for mail*, 26 Winans St., E. Orange, N. J.
SHAW, Louis E. ('13), Cons. Engr., 179 N. Oraton Pkwy.
SMITH, Peter A. ('26), Treas., A. P. Smith Mfg. Co.; 545 N. Arlington Ave., E. Orange; *for mail*, 66 Stanley Rd., S. Orange.
SPENCER, Chas. W. (J'34), 404 N. Arlington Ave.
STEWART, Ethan A. ('31; '35), Ch. Engr., Power Plant, Continental Can Co., 16th & Coles Sts., Jersey City; *for mail*, 51 N. 21st St., E. Orange.
SWAIN, Wilbur A. ('18; A'24), 90 Evergreen Pl.
TALLMADGE, Webster ('11; '13; '25), Pres., Webster Tallmadge & Co., Inc., 255 N. 18th St.
TURNO, Walter G. ('13; '16; '21), 71 Lafayette Ave.
TUTHILL, Elmer S. (J'23), Architect, 360 Main St.
VanDERBEEK, Wm. L. (J'35), Time Study Engr. Clark Thread Co.; 54 Clark St., Newark; *for mail*, 43 Newfield St., E. Orange.
WEBSTER, Sidney H. (J'31), Serv. Engr., Eclipse Aviation Corp., 545 N. Arlington Ave.
WENTWORTH, E. Francis ('22; '30), Sales Engr. N. Y. Air Brake Co., 420 Lexington Ave., New York, N. Y.; *for mail*, 36 Washington Terrace, E. Orange, N. J.
WILKINSON, A. S. (J'33), 249 S. Arlington Ave.
WRIGHT, Lysander E. ('23), 71 Mitchell Pl.
WYCKOFF, Norman W. (J'34), Time & Motion Analyst, Westinghouse Elec. & Mfg. Co., Orange St., Newark; *for mail*, 258 S. Burnett St., E. Orange.
WYLLIE, John S. (J'21), 4 Birchwood Ave.
ZWACK, Raymond T. (J'31), Student Engr., N. J. Bell Tel. Co.; *for mail*, 474 N. Maple Ave.

EAST RUTHERFORD, Metropolitan Section

LEUANG, Wm. A. (J'35), 271 Carlton Ave.
LINKER, John I. ('21; '25; '35), Ch. Engr., Flintkote Co., Oak St.

EDGEWATER, Metropolitan Section

BLIRER, Arthur E. (J'35), Student Engr., Aluminum Co. of Am., River Rd.; *for mail*, 16 Adelaide Pl.
GULLIKSEN, John W. (J'26), Ch. Estimator Aluminum Co. of Am., Edgewater; *for mail* 81—29th St., Woodcliff.
MALBY, Seth G. ('21), Aluminum Co. of Am., Edgewater; *for mail*, Tenafly.
WEIR, Chester I. ('32), 1200 River Rd.
WEIR, Wm. F. (J'34), Time Study Engr., Aluminum Co. of Am.
WILLSEA, Raymond (J'34), Estimator, Aluminum Co. of Am.

ELIZABETH, Plainfield Section

ABRAMS, Victor R. ('36), Ch. Engr., Sulflo Corp. of Am., 701 Spring St., Elizabeth; *for mail* 77 S. Munn Ave., E. Orange.
ANDERSON, Thos. ('24; '35), Research Engr., Doherty Research Co., 47-32 Van Dam St., Long Island City, N. Y.; *for mail*, 14 Clover St., Elizabeth, N. J.
ATKINSON, Vernon L. (J'27), Tech. Serv. Div., Stand. Oil Co. of N. J., P. O. Box 276, Elizabeth; *for mail*, P. O. Box 446, Elmwood Terrace, W. Caldwell.
BARLOW, Edwin H. ('13; '23), Ch. Engr., Stand. Oil Devel. Co., Box 37.
BENDICK, Marc (J'34), Volupte Inc., P. O. Box 204, Elizabeth, N. J.; *for mail*, 235 W. 71st St., New York, N. Y.
BONNETT, L. B. ('11), Retired; 310 W. Jersey St.
BOWERS, Jas. A. (J'26), Asst. Ch. Engr., Charge Design, Bendix Mar. Products Co., Inc., 754 Lexington Ave., Brooklyn, N. Y.; *for mail* 151 Chilton St., Elizabeth, N. J.
BRUGGER, Richard (J'36), Jr. Engr., Sperry Products, Inc., 40 Flatbush Ave. Ext., Brooklyn, N. Y.; *for mail*, 356 Monmouth Rd., Elizabeth, N. J.
BURGOMASTER, John E. ('31; '35), 1141 Chestnut St.
BURRITT, Leslie D. (J'22), Engr., Gen. Engrg. Dept., Stand. Oil Devel. Co., Box 37, Elizabeth; *for mail*, 609 Chestnut St., Westfield.
CAMPBELL, John, Jr. (J'33), 331 Elmora Ave.
CHASON, Daniel H. ('21; '29), M. E., Charge Methods & Equip., Singer Mfg. Co., Elizabethport; *for mail*, 843 Park Ave., Elizabeth.
CHICKERING, John Abbott (J'34), 20 Chilton St.
COCKE, M. Estes, Jr. (J'34), M. E., Bayway Refinery, Stand. Oil Co. of N. J.; *for mail*, 80 Palisade Rd.
COHEN, Irving, (J'34), 456 Livingston St.
DICK, Arthur C. (J'31), Process Engr., Stand. Oil Co. of N. J.; *for mail*, 635 Westfield Ave.
EDMONDSON, W. G. ('17), Secy., Treas., Elmora Mfg. Co., 50 Columbia St., Newark; *for mail*, 765 N. Broad St., Elizabeth.

ELLY, Robt. Duncan (J'32), Sales Engr., Electroloy Co., Inc., 50 Church St., New York, N. Y.; *for mail*, 126 De Hart Pl., Elizabeth, N. J.
ELY, Allen J. ('20; '25; '27), M. E., Stand. Oil Devel. Co., P. O. Box 37.
FOSTER, J. S. ('91; '03), V. P., Ch. Engr., Lidgerwood Mfg. Co., 775 Lidgerwood Ave.
FOX, Frank W. ('19; '35), Chmn., Fuel Economy Comm., Tech. Serv. Div., Stand. Oil Co. of N. J., Elizabeth; *for mail*, 9 Fair Hill Rd., Westfield.
GAMBLE, Walter W. ('19), Mgr., Mech. & Power Opera., 3 N. J. Plants, Stand. Oil Co. of N. J., Bayonne; *home address*, 42 Aberdeen Rd., Elizabeth.
GOOD, Robt. H. ('23), Gen. Supt., Moore Bros. Co., Bond & Pine Sts.; *for mail*, 228 Stiles St.
HESSELBACH, Chas. F. ('23; '23), Engr., Stand. Oil Devel. Co.; *for mail*, 9 Gibson Pl.
HUETTL, Wm. A. ('31; '35), Designers, Watson-Stillman Co., Aldene Rd., Roselle; *for mail*, 618 Floral Ave., Elizabeth.
JACOBSON, Saul B. (J'34), 1269 Clinton Pl.
KERR, Jos. ('22; '35), Asst. Editor, Product Engineering, McGraw-Hill Publ. Co., 330 W 42nd St., New York, N. Y.; *for mail*, 14 Palisade Rd., Elizabeth, N. J.
KOPF, Wm. F. (J'24), 626 Park Ave.
LAWRENCE, Frank V. ('21), Gen. Mgr., Interstate Equip. Corp., 18 W. Jersey St., Elizabeth; *for mail*, 1314 Denmark Rd., Plainfield.
LEWIS, Harry I. ('16; '25), V. P., Am. Type Founders Co., Elizabeth, N. J.
MENSHON, W. R. ('28; '35), Plant Supt., Barrett Co., 86 Elizabeth Ave.
METZNER, Bruno C. ('27; '29; '35), Abstractor, Library, Stand. Oil Devel. Co., Box 243, Elizabeth; *for mail*, 964 Townley Ave., Union.
MOTT, Cliff J. ('24; '35), M. E., Stand. Oil Co of N. J., Box 37, Elizabeth; *for mail*, 45 Gillespie Rd., Bloomfield.
NOHSE, Wm. R. E. (J'21), Draftsman, Cent. R. R of N. J., Elizabeth, N. J.; *for mail*, 136 E. 17th St., New York, N. Y.
OESTNAES, Victor L. ('27), Ch. Engr., Am. Gas Accumulator Co., Elizabeth; *for mail*, 905 Summit Ave., Westfield.
OSTERMAN, Philip C. ('12), V. P., Am. Gas Furnace Co.; *for mail*, 19 Stiles St.
PEETS, Wilbur J. ('14; '35), Asst. Supt., Charge Engrg., Singer Mfg. Co., Trumbull St.; *for mail*, 973 Coolidge Rd.
REICHERT, W. G. ('32), Engr., Singer Mfg. Co., Elizabeth; *for mail*, 330 E. Lincoln Ave., Roselle Park.
ROBERTS, David S. ('22; '25; '35), Const. Engr., Stand. Oil Devel. Co., P. O Box 37, Elizabeth; *for mail*, 415 Everson Pl., Westfield.
SCHNACKEL, Harry G. ('29; '35), Secy., Treas. & Dir., Davis Engrg. Corp., 1068 E. Grand St., Elizabeth; *for mail*, 11 Dunham Ave., Cranford.
SCHWAB, Gustav ('12; '25), Sales Engr., Am. Gas Furnace Co., Spring & Lafayette Sts., Elizabeth; *for mail*, 730 Golf Terrace, Roselle.
SLOANE, Reginald G. ('30; '35), Chem. Engr., Stand. Oil Devel. Co., P. O. Box 243.
TAYLOR, Arba S. ('26; '32; '35), Ch. Test Engr., Bayway Refinery, Stand. Oil Co. of N. J., Elizabeth; *for mail*, 234 Walnut St., Roselle.
TYROFF, Carl E. ('22; '35), Constr. Engr., Stand. Oil Co. of N. J., Elizabeth; *for mail*, 247 W. 4th Ave., Roselle.
UPDEGRAFF, Wm. B. ('10), V. P., Sales, Watson Stillman Co., Roselle; *for mail*, 384 Elmora Ave., Elizabeth.
von ZASTROW, Eberhard ('29; '35), Plant Engr., Maint. & Constr., Gen. Aniline Wks., Inc., Grasselli; *for mail*, 1039 Harding Rd., Elizabeth.
WADE, E. Annesley (J'34), Indus. Engrg. Dept., Product & Sales Engrg., Am. Hard Rubber Co., Butler; *for mail*, 539 Chilton St., Elizabeth.
WALSH, Craig (J'34), 34 De Hart Pl.
WINTRITZ, Geo. (J'31), 521 Muriel Pkwy.
WRIGHT, Donald L. (J'30), M. E., Stand. Oil Devel. Co., Box 485; *for mail*, 252 Lincoln Ave.

ELIZABETHPORT, Plainfield Section

HASSELL, Richard A. (J'33), Student, Tool Making, Singer Mfg. Co., Trumbull St., Elizabethport; *for mail*, 1025 Madison Ave., Plainfield.
JOHNSON, Fred E. ('21; 35), M. E., Design of Prod. Equip., Singer Mfg. Co., Trumbull St., Elizabethport; *for mail*, 246 Dorer Ave., Hillside.
KAIER, Richard (J'19), Asst. Mgr., Hardening Dept., Singer Mfg. Co., Elizabethport; *for mail*, 109 Pine St., Cranford.
KARLE, John D. ('22), M. E., Design Auto. Mchy., Singer Mfg. Co., Elizabethport; *for mail*, 320 Chestnut St., Roselle Park.
KOPF, Emil A. ('18; '35), M. E., Design Automatic Mchy., Methods, Singer Mfg. Co., Elizabethport; *for mail*, 214 E. Clay Ave., Roselle Park.
MELZIG, Alfred H. J. ('23), Method & Equip. Overseer, Singer Mfg. Co., Elizabethport; *for mail*, 277 E. 2d Ave., Roselle.
NYDEGGER, Paul F. ('21), Supt., Singer Mfg. Co.

ENGLEWOOD, Metropolitan Section

CLARY, Frank A., Jr. (J'33), 86 Spring Lane.
KNOX, S. L. G. ('92; '01), 95 Woodland St.
ROBERTS, Montague H. ('12; '17), V. P., Franklin Ry. Supply Co., Inc., 60 E. 42nd St., New York, N. Y.; *home address*, 124 Linden Ave., Englewood, N. J.
SCHELLENS, Eugene L. ('30), Ch. Engr., J. S. Coffin, Jr., Co., Englewood; *for mail*, 372 Upper Blvd., Ridgewood.
SCHENK, Everett M. (J'36), 89 Engle St.

ERLTON, Philadelphia Section

YOUNG, Thos. F. (J'31), Tool Design, RCA Victor Div., RCA Co., Inc., Camden; *for mail*, 32 Harrison Ave., Erlton.

FANWOOD, Plainfield Section

WINSHIP, Wm. R. ('29; '35), 229 Herbert Ave.

FLORENCE, Philadelphia Section

BROWN, Warren A. (J'29), Asst. to Supt., Florence Pipe Fdy. & Mch. Co., Front St.; *for mail*, 12 Church St.

FORDS, Plainfield Section

FRITZ, Chas. G. ('36), M. E., Charge Maint., Atlantic Terra Cotta Co., Buckingham Ave., Perth Amboy; *for mail*, 60—3d St., Fords.

GARFIELD, Metropolitan Section

GRUPE, Wm. F. ('13; '21; '35), V. P., Charge Sales, Chambon Corp., Outwater Lane & Spruce St.
HAMERSLEY, Carl S. ('19), Pres., Hamersley Mfg. Co., Inc., 65 River Dr.

GIBBSTOWN, Philadelphia Section

PILCHER, Wm. S. (J'32), E. I. du Pont de Nemours & Co.

GLEN RIDGE, Metropolitan Section

ALLEN, Frank B. (J'35), 63 Ridgewood Ave.
BURROUGHS, Jos. H., Jr. ('11; '13), Checker, Devel. Dept., Drafting Rm., Carrier Corp., 850 Frelinghuysen Ave., Newark; *for mail*, 48 Hillside Ave., Glen Ridge.
FAUSEL, Chas. A. (J'26), Mch. Designer, 6 Wildwood Terrace.
JONES, Harold L. ('19; '25; '26), V. P., W. W. Farrier Co., 44 Montgomery St., Jersey City; *home address*, 11 Cambridge Rd., Glen Ridge.
MacARTHUR, Chas. J. ('32), Engr., Charge Ptg. Research, Internatl. Ptg. Ink. Corp., Research Labs., 432 W. 45th St., New York, N. Y.; *home address*, 296 Ridgewood Ave., Glen Ridge, N. J.
PRICE, Towson ('25), Asst. Atty., Pat. Dept., Westinghouse Lamp Co., Bloomfield; *home address*, 235 Forest Ave., Glen Ridge.
SCHEFFLER, Fred'k A. ('83), Retired; 293 Ridgewood Ave.
WORDEN, Euclid P. ('99; '02), Cons. Engr., 1 Hamilton Rd.

GLEN ROCK, Metropolitan Section

BLIXT, Gustaf F. ('16; '23), 73 Rodney St.
GROSSHEIM, Max K. ('17; '35), 90 S. Highwood Ave.
MIEDENDORP, Henry, Jr. ('28), Cons. Textile Engr., 16 Lee Ave.
RAMSEY, Clifford H. ('20), Pres., Morrison Mch. Co., 1171-1225 Madison Ave., P. O. Box 1690, Paterson; *home address*, 515 S. Maple Ave., Glen Rock.
SMITH, Thos. C. (J'28), 29 Ashton Pl.

GLOUCESTER CITY, Philadelphia Section

WEGENER, Francis A. (J'15), V. P., Gen. Mgr., Welsbach Co., Gloucester City.

GRANTWOOD, Metropolitan Section

CROUCH, Calvin H. ('98; '08), Apt. 1-1N, 755 Anderson Ave.
EINBECK, August Carl, Jr. (J'36), 57 Lawton Ave.
SCHWARZWALDER, Robt. F. (J'30), Sales Engr., Atlantic Gear Works, Inc., 128 Lafayette St., New York, N. Y.; *for mail*, 51 Lawton Ave., Grantwood, N. J.

GRASSELLI, Plainfield Section

CHANDLER, Howard M. ('13), M. E., Plant Layout, Plaskon Co., Inc., Grasselli, N. J.; *for mail*, 109-28—212th St., Bellaire, L. I., N. Y.
WITTIG, Fred'k E. (J'36), Jr. Engr., Maint. & Constr. Dept., Grasselli Chem. Co.

GREAT NOTCH, Metropolitan Section

HOBSON, Russell B. ('15), Holly Gravity Return System.

GREEN POND, Metropolitan Section

WATERS, Geo. H. ('01), Gen. Mgr., Green Pond Corp.

HACKENSACK, Metropolitan Section

BERGER, Edwin B. (J'26), Rep., Timken-Detroit Co., Hackensack; *for mail*, 890 Edgewater Ave., Ridgefield.
KOEPPEL, Chas. H. (J'35), 276 Hamilton Pl.
McGRATH, Harold Daniel (J'36), Supvr. & Estimator, Jas. McGrath Co., 185 Moore St.
ROTH, Willard E. ('20; '35), Publicity, Advertising, Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail*, 60 Willow Ave., Hackensack, N. J.
ZIMMERMAN, Howard Thurlow (J'29), Supt., Ralph B. Carter Co., 192 Atlantic St.

HADDONFIELD, Philadelphia Section

HANSON, Milton E. ('19; '27), M. E., Charge Design, B. F. Sturtevant Co., Crestmont & Haddon Ave., Camden; *for mail*, 408 Chews Landing Rd., Haddonfield.
JOHNSON, Edw. F., Jr. (J'36), 33 Estaugh Ave.

HARRINGTON PARK, Metropolitan Section

VAN DE COP, Karel ('22; '25; '35), M. E., Fruit Dispatch Co., Pier 7, N. R., New York, N. Y.; *for mail*, Harriet Ave., Harrington Park, N. J.

HARRISON, Metropolitan Section

ALLAN, Wm. T. (A'06), Mem. Firm, A. Allan & Son, 6th & Bergen Sts.
ASSAYKEEN, Ivan V. ('28), Field Engr., Worthington Pump & Mchy. Corp., Harrison; *for mail*, 355 Wyoming Ave., S. Orange.
AUER, Gustavus ('27; '35), Sales Engr., Worthington Pump & Mchy. Corp., Harrison, N. J.; *for mail*, 2013 Ridley St., Germantown, Philadelphia, Pa.
CLARY, Willard Butler (J'28), Worthington Pump & Mchy. Corp.
DISE, Lawrence R. (J'24), Test Engr., Worthington Pump & Mchy. Corp., Harrison; *for mail*, 71 Alpine Pl., Arlington.
DISERENS, Paul ('08; '16), Cons. Engr., Worthington Pump & Mchy. Corp.
DORER, Oscar H. ('12; '21; '35), Asst. Mgr., Centrifugal Pump Div., Worthington Pump & Mchy. Corp., Harrison; *for mail*, 47 Arsdale Terrace, E. Orange.
EDDY, Herbert S. (J'35), R. C. A. Radioton Div., 415 S. 5th St., Harrison; *for mail*, 23 Beech St., E. Orange.
ESKIN, Benj. (J'32), Checker under Dyre Engrg. System, Worthington Pump & Mchy. Corp., Harrison; *for mail*, 84 Grumman Ave., Newark.
FLINT, Warren E. ('23; '25; '35), M. E., John J. Cavagnaro, Harrison; *for mail*, 504—2nd St., Palisades Park.
FROMM, Dr. Carl ('24), M. E., Sales Dept., Worthington Pump & Mchy. Corp., Harrison; *for mail*, 193 Scheerer Ave., Newark.
GRACE, John F. ('15), Condenser Engr., Worthington Pump & Mchy. Corp., Harrison; *for mail*, 24 Alpine Pl., Arlington.
GRAF, Wm., Jr. (J'29), Ejector Engr., Worthington Pump & Mchy. Corp., Harrison; *for mail*, 290 Berkley Ave., Bloomfield.
HABACH, Geo. F. (J'29), Designer, Worthington Pump & Mchy. Corp., Harrison; *for mail*, 714 Valley St., Orange.
HALL, Rodney Dennis ('02; '08), Mgr., Water Wks. Sales, Worthington Pump & Mchy. Corp.
HENDRIE, Chas. F. ('21; '29; '35), Asst. Mgr., Steam Power Div., Worthington Pump & Mchy. Corp.
HORSMAN, K. W. ('35; '35), Field Engr., Worthington Pump & Mchy. Corp.
JACKSON, Wm. Geo. ('32), Devel. Engr., Hyatt Bearings Div., Gen. Motors Corp.
JAGIENTOWICZ, Theodore A. (J'35), 213 Manor Ave.
KENNEDY, Chas. Arthur (J'32), Application & Sales Div., Worthington Pump & Mchy. Corp., Worthington Ave., Harrison; *for mail*, 64 Park Ave., Bloomfield.
KNOOP, Theo. M. ('04; '16), Asst. to Mgr., Condenser Dept., Worthington Pump & Mchy. Corp., Harrison, N. J.; *for mail*, 25 Clarkson Ave., Brooklyn, N. Y.

LEVINE, Harry (J'30), Machinist, Otis Elevator Corp., Harrison, N. J.; *for mail,* 269—15th St., Brooklyn, N. Y.
LEWIS, Irving R., Jr. (J'34), Devel. Engr., Worthington Pump & Mchy. Corp., Harrison; *for mail,* 2115 Park Ave., Plainfield.
LLOYD, John A. (J'36), Oil Refining & Marketing Div., Worthington Pump & Mchy. Corp.
MILLER, Herman H. (A'16), Mgr., Compressor Dept., Worthington Pump & Mchy. Corp., Buffalo, N. Y.; *for mail,* Harrison, N. J.
MOCKRIDGE, Chester R. (J'22), Centrifugal Pump Engr., Worthington Pump & Mchy. Corp., Harrison; *for mail,* 52 Edgar Pl., Nutley.
NEILL, Wm. A. ('18), Mgr., Min. & Constr. Dept., Worthington Pump & Mchy. Corp., Harrison; *for mail,* 160 Prospect St., E. Orange.
PARKER, A. Wilbur ('92; '01), Engr., Publicity, Worthington Pump & Mchy. Corp., Harrison; *for mail,* 262 Sylvan St., Rutherford.
SEIDLER, Mason F. (J'26), Member, Methods & Stands. Dept., Worthington Pump & Mchy. Corp., 401 Worthington Ave., Harrison; *for mail,* 4361 Hudson Blvd., N. Bergen.
SIZER, Wm. D. ('22; '33), Mgr., Centrifugal Engrg. Div., Worthington Pump & Mchy. Corp.
THOMSON, A. Morris ('29), Pres., T. C. M. Mfg. Co., 300—1st St.
WADDELL, C. L. ('36), Engr., Charge Condensers & Heaters, Worthington Pump & Mchy. Corp., Harrison; *for mail,* Conklin Ave., Morristown.
WISLICENUS, Geo. F. (J'30), Engr., Design, Worthington Pump & Mchy. Corp., Worthington Ave., Harrison; *for mail,* 727 Valley St., Orange.
WRIGHT, Elliott F. (J'35), Devel. Engr., Worthington Pump & Mchy. Corp., Harrison, N. J.; *for mail,* 7 Montague Pl., Brooklyn, N. Y.

HASBROUCK HEIGHTS, Metropolitan Section

HETTINGER, Chas. ('32; '35), M. E., Charge Maint., Anchor Cap & Closure Corp., Long Island City, N. Y.; *for mail,* 311 Passaic Ave., Hasbrouck Heights, N. J.
KUPERIAN, Wilbur J. (J'33), Pat. Atty., Union Carbide & Carbon Co., 30 E. 42nd St. New York, N. Y.; *home address,* 158 Kipp Ave., Hasbrouck Heights, N. J.

HAWORTH, Metropolitan Section

RYAN, W. R. (J'34).
WEST, Ernest H. (A'17), Comptroller, Union Carbide Co., 30 E. 42nd St., New York, N. Y.; *for mail,* Sunset Ave., Haworth, N. J.

HAWTHORNE, Metropolitan Section

ANDERSON, John H. (J'34), Prod. Engr., Linen Thread Co., Inc., 418 Grand St., Paterson; *for mail,* 159 Diamond Bridge Ave., Hawthorne.
LOWER, Nathan M. ('13), Exper. Engrg., 29 Utter Ave.
STEWART, Randall E. ('36), Suprv., Engrg. Dept., Continental Asbestos & Refining Corp., 1 Madison, New York, N. Y.; *for mail,* 306 Diamond Bridge Ave., Hawthorne, N. J.
ZWINGLI, Carl T. ('20; '30), M. E., E. E., Am. Agri. Chem. Co., 50 Church St., New York, N. Y.; *for mail,* 35 Elberon Ave., Hawthorne, N. J.

HIGH BRIDGE

ALEXANDER, Edward E. (A'08), M. E., Taylor-Wharton Iron & Steel Co.; *for mail,* High Bridge.
FREDERICK, Rheuel H. ('20), Designer, Estimator, Taylor-Wharton Iron & Steel Co.; *for mail,* P. O. Box 144.
HANKS, Geo. R. ('24), Pres., Taylor-Wharton Iron & Steel Co.
STIRES, Wm. H. ('19; '27), M. E., Taylor-Wharton Iron & Steel Co.; *for mail,* P. O. Box 244.

HILLSDALE, Metropolitan Section

TUFTS, Lesley R. ('24), Engr., Dexter Folder Co., Pearl River, N. Y.; *for mail,* 47 Cherry Pl., Hillsdale, N. J.

HILLSIDE, Metropolitan Section

BRENGEL, Fred'k J. ('14; '16; '21), 1131 Salem Ave.
CONRAN, Fred M. ('14; '35), Designer, Bldr., Spec. Mchy., 1275 Robert St.
DAVIDSON, Edw. H. ('31; '35), Loco. Inspr., Interstate Commerce Comm., 433 Post Office Bldg., Newark; *home address,* 170 Hillside Ave., Hillside.
DEAN, Frederic E. ('25; '30), Engr., Fed. Communications Comm., Washington, D. C.; *for mail,* 21 Parkview Terrace, Hillside, N. J.

HOBOKEN, Metropolitan Section

BROCKEL, Wm. E. (J'30), Condenser Serv. & Engrg. Co., Inc., 310—12th St., Hoboken; *for mail,* 28—20th Ave., Irvington.
BURHORN, Edwin ('14), Pres., Edwin Burhorn Co., 1 Newark St.
DAVIDSON, Kenneth S. M. ('24; '31; '35), Asst. Prof. M. E., Stevens Inst. of Tech.; *for mail,* Castle Point.
DAVIS, Harvey N. ('20; F'36), Manager, '29-'30; Vice-President, '30-'32; Pres., Stevens Inst. of Tech.
DEIMEL, R. F. ('29), Prof. M. E., Stevens Inst. of Tech.
ENNIS, Wm. D. ('98; '07), Treasurer, '35 to date; Humphreys Prof., Stevens Inst. of Tech.
FEZANDIÉ, Eugène H. ('22; '26; '30), Asst. Prof., Dept. M. E., Stevens Inst. of Tech.
FURMAN, Franklin DeR. ('02), Dean & Prof. Mch. Design, Stevens Inst. of Tech.
GILLILAND, Leonard R. (J'27), Dept. Mgr., Am. Pencil Co., 500 Willow St.
HALLIDAY, Wm. R. ('13), Assoc. Prof., Dept. Mch. Design, Stevens Inst. of Tech., 5th & Hudson Sts.
HASHAGEN, John B. (J'20,) Engr., Franklin Baker Co., 15th & Bloomfield St., Hoboken; *for mail,* 121 Manhattan Ave., Jersey City.
JACOBUS, David D. ('24; '34), Asst. Prof., Stevens Inst. of Tech.; Dir., Chem. Research Lab., Keuffel & Esser Co., 300 Adams St. (*latter address for mail*).
JENNES, Adrien, Jr. (J'34), 106—5th St.
JUELSS, Dave ('35), Engr., Charge Maint. & Design, Am. Pencil Co., 500 Willow Ave.
KENNEDY, Wm. M. ('30), Gen. Mgr., Condenser Serv. & Engrg. Co., Inc., 310—12th St., Hoboken; *for mail,* 335 Lyndhurst Ave., Lyndhurst.
KEUFFEL, Carl W. ('13; '26), Exec., Mfg. Dept., Keuffel & Esser Co., 3rd & Adams Sts.
KINSEY, Alfred S. ('13), Prof., Shop Practice, Stevens Inst. of Tech.
LAMBELET, Carl H. (J'13), Pres., N. J. Mch. Corp., 16th & Willow Ave.
LEIGH, Richard Shipman (J'32), Engr., Power Plant, A. I. Namm & Son, Inc., 452 Fulton St., Brooklyn, N. Y.; *for mail,* 610 River St., Hoboken, N. J.
NORRIS, Alfred G. ('19; '24), Administrative Asst. & Advis. Engr., Works Progress Admin., 6 E. 39th St., New York, N. Y.; *for mail,* 507 River St., Hoboken, N. J.
PARRELLO, Fulvo (J'33), Engr., Condenser Serv. & Engrg. Co., Inc., 310—12th St.
PRANDONI, Jos. Francis (J'29), Asst. Engr., Findlay Engrg. Corp., 1311 Hudson Ave., Hoboken; *for mail,* 308 Seventh St., Union City.
RECKFORD, John King ('16; '26; '35), V. P., Am. Lead Pencil Co.
SIEVERS, E. J. J. ('10; '23; '35), 65 Willow Ave.
SPEER, Geo. R. (J'31), 1019 Garden St.
THIELKER, Henry J. ('24; '26; '35), Ch. Engr., Triplex Safety Glass Co., Lipton Bldg., Hoboken, N. J.; *for mail,* 1511 St. Peters Ave., New York, N. Y.
TREFNY, Ladislaw Edw. (J'31), Draftsman, Keuffel & Esser Co., 3rd & Adams St., Hoboken, N. J.; *for mail,* 40-41 100th St., Corona, L. I., N. Y.
VIDOSIC, Jos. (J'32), 834 Hudson St.
YELLOTT, John I. (J'31), *Junior Award,* '34; Asst. Prof. M. E., Stevens Inst. of Tech.

IRVINGTON, Metropolitan Section

BONANNO, Jos. L. ('30), Mgr., C. B. Engrg. Co., Sager Pl., Irvington, N. J.; *for mail,* 71 Colonial Ave., Forest Hills, L. I., N. Y.
CASTELLANO, Frank S. ('35; '35), Lab. Foreman, Pub. Serv. Elec. & Gas Co., 938 Clinton Ave., Irvington; *for mail,* 1288 Barr Ave., Hudson Heights.
EBERHARDT, Fred'k L. ('89; '02), Pres., Gould & Eberhardt, Irvington; *for mail,* 629 Prospect St., Maplewood.
EBERHARDT, H. Ezra ('13; '21), Secy., Gould & Eberhardt, 433 Fabyan Pl., Irvington; *for mail,* 2 Mountain View Terrace, Maplewood.
KASSNER, Paul A. ('30; '33; '35), M. E. & Designer, Mergenthaler Linotype Co., Brooklyn, N. Y.; *for mail,* 97 S. 22nd St., Irvington, N. J.
LEONARD, Malcolm W. ('23), Asst. Ch., Mech. Div., Testing Labs., Pub. Serv. Elec. & Gas Co., 938 Clinton Ave., Irvington; *for mail,* 35 Orchard Rd., Maplewood.
PICKETT, Louis (J'28), Designer, Reliable Tool Co., 60 Coit St.; *for mail,* 58 Harrison Pl.
STAPFER, Rudolf D. (J'29), Lab. Asst., Pub. Serv. Elec. & Gas Co., 21st St. & Clinton Ave., Irvington; *for mail,* 534 Hawthorne Ave., Newark.
SUTER, Frank F. ('21; '35), Instr. Mech. Drafting, Essex County Vocational Sch., Myrtle Ave. & University Pl.; *for mail,* 67 Linden Ave.
VASSAR, Hervey S. ('14), Lab. Engr., Pub. Serv. Elec. & Gas Co., 938 Clinton Ave.
WALKAMA, T. Edw. ('27; '34; '35), Engr., Power Plant Test., Pub. Serv. Elec. & Gas Co., 938 Clinton Ave., Irvington; *for mail,* 145 Terhune Ave., Jersey City.
WILHELEM, Oscar F. ('31; '33), Supt., Marathon Razor Blade Co., Inc., 125 Coit St., Irvington, N. J.; *for mail,* 102-14 Remington St., Jamaica, L. I., N. Y.

JERSEY CITY, Metropolitan Section

ALDRICH, Richard C. (J'33), Engr., M. W. Kellogg Co., Danforth Ave., Jersey City, N. J.; *for mail,* 317 W. 74th St., New York, N. Y.
ANBRO, Gosta A. ('24; '35), Power Engr., Colgate-Palmolive-Peet Co., 105 Hudson St.
BARRANCE, Jas. A. ('29; '35), 169 Clinton Ave.
BEAN, Philip H. ('22; '35), W. End Gas Wks.
BERRIAN, Kenneth J. (J'35), 615 Palisade Ave.
BUTLER, Chas. A. ('21; '35), Salesman, J. E. Lonergan Co., 211 Race St., Philadelphia, Pa.; *for mail,* 46 Astor Pl., Jersey City, N. J.
CARR, G. Everett ('23; '35), Indus. Engr., C. F. Mueller Co., 180 Baldwin Ave., Jersey City; *for mail,* 343—5th St., Ridgefield Park.
CHRISTY, Wm. G. ('19), Smoke Abatement Engr., Charge Smoke Regulation Dept., Hudson County, Court House.
COWGILL, W. W. ('33), Exec. V. P., Sardik, Inc., 15 Exchange Pl., Jersey City, N. J.; *for mail,* Greenfield Hill, Fairfield, Conn.
CURREY, John J. ('23), Supt., Mch. & Pipe Shops, M. W. Kellogg Co., Foot of Danforth Ave., Jersey City; *for mail,* 140 Sylvan St., Rutherford.
CZERWINSKI, Francis A. ('35; '35), 229 Lembeck Ave.
DAVEY, Warren ('99; '16), Ch. Engr., Tech. Div., Colgate-Palmolive-Peet Co., 105 Hudson Street.
DAVIES, Thos. H. ('17; '35), Supt., M. E., Carbide & Carbon Realty Co., 30 E. 42nd St., New York, N. Y.; *home address,* 217 Pearsall Ave., Jersey City, N. J.
ECKERT, Henry R. ('21; '31), Owner, Hudson Refrig. Mch. Co., 180 Clerk St.
EDWARDS, Henry Hartley (J'36), M. E., Maint. & Mgmt., Porete Mfg. Co., Porete Ave., N. Arlington; *for mail,* 82 Randolph Ave., Jersey City.
EHRHARDT, John J. ('16; '24), 302 Stegman Pkwy.
FERRINI, Hannibal P. (J'31), Teacher, Electricity, Wm. L. Dickinson High Sch., Palisade & Newark Ave.; *for mail,* 36 Laidlow Ave.
FOLEY, Jas. A. ('29), Mech. Bridge Engr., Hudson County Engrg. Dept., Court House; *for mail,* 439 Fairmont Ave.
GLAUCH, Edmund S. ('20; '30), M. E., Lubricants Dept., Jos. Dixon Crucible Co., Jersey City; *for mail,* 49 Diamond Bridge Ave., Hawthorne.
GOERG, Emil F. (A'22), Supt., Charge Mfg., Air Reduction Co., Inc., 191 Pacific Ave., Jersey City; *for mail,* 400 S. Washington Ave., Dunellen.
GRIGGS, Robt. A. (J'30), Asst. to Cons. Engr., Colgate-Palmolive-Peet Co., Jersey City, N. J.; *for mail,* Apt. A4, 266 Washington Ave., Brooklyn, N. Y.
HASBROUCK, David M. ('23; '35), Wks. Mgr., Air Reduction Sales Co., 181 Pacific Ave.
HERBERMANN, Chas. G. (J'31), Export S. S. Corp., Pier F.
HODGES, John L. ('24; '26; '31), Deputy Smoke Abatement Engr., Smoke Regulation Dept., Hudson County, Court House.
HOLLOWELL, Jas S. ('30), M. E., Dir. Constr., Natural Products Refining Co., 902 Garfield Ave.
HOPKINS, Robt. K. ('25; '31), Dir. of Metal. Research & Devel., M. W. Kellogg Co., Foot of Danforth Ave., Jersey City, N. J.; *for mail,* 15 St. Austins Pl., W. Brighton, S. I., N. Y.
IVORY, Henry Vincent (J'36), 92 South St.
JACOBS, Jay A. ('27; '35), Plant Engr., Colgate-Palmolive-Peet Co., 105 Hudson St.
KIDD, Alex ('30; '34), Pressure Vessel Design Engr., M. W. Kellogg Co., Danforth Ave., Jersey City; *for mail,* 9 Summit Rd., Allwood.
KNEZO, John, Jr. (J'35), 123 Maple St.
KRISTO, Fred J. (J'29), Prod. Engr., Bond Elec. Corp., 257 Cornelison Ave., Jersey City; *for mail,* 206 Shepard Ave., Teaneck.
LINDSTROM, Nils O. ('03), Gen. Supt., A. B. See Elev. Co., Inc., 150 Pacific Ave.
LINDSTROM, Oscar W. (A'30), Shop Mgr., A. B. See Elev. Co., Inc., 150 Pacific Ave.
LOGAN, Maurice H. (A'16), Div. Sub Sta. Opera., Hudson Div., Pub. Serv. Elec. & Gas Co., 323 Palisade Ave.; *for mail,* 11 Nesbitt St.
LUCARELLI, Benj. J. (J'30), Asst. Ch. Draftsman, M. E., N. Y. Quotation Co., 41 Broad St., New York, N. Y.; *for mail,* 1855 Boulevard, Jersey City, N. J.
MILLSPAUGH, Gordon A. ('27), Ch. Engr., S. S. Excalibur, Am. Export Lines, Pier F, Exchange Pl., Jersey City; *for mail,* 560 Westminster Ave., Elizabeth.
NICOLICH, Mark J. (J'34), 933a Summit Ave.
QUINN, John B. (J'32), 118 Randolph Ave.

SCHAFER, Sidney P. ('24; '25; '35), East Can. Sales Mgr., Racine Tool & Mch. Co., Racine, Wis.; *for mail*, Box 175, Journal Sq. Sta., Jersey City, N. J.
SCHWARTZ, Alfred (J'36), 256 Liberty Ave.
SCOTT, W. E. ('32), Plant Engr., Continental Can Co., Inc., 16th & Coles Sts.; *for mail*, 283 Bergen Ave.
SIEBER, Wm. J. ('29; '35), M. W. Kellogg Co., Danforth Ave., Jersey City, N. J.; *for mail*, 154 Pennsylvania Ave., Freeport, L. I., N. Y.
SIMPSON, Roswell H. ('15; '27), Factory Engrg. & Designing, Jos. Dixon Crucible Co., Wayne & Monmouth Sts., Jersey City, N. J.; *for mail*, 81 Hillside Terrace, Great Kills, S. I., N. Y.
SMITH, Benj. C. ('25), Pres., Stand. Motor Constr. Co., 180 Whiton St.
SULLO, Kenneth (J'36), M. E. Shop Asst., Fed. Shipbldg. Co., Kearny, N. J.; *for mail*, Y. M. C. A., 654 Bergen Ave., Jersey City.
TOMPKINS, Harold D. ('17; '26), Treas., Engr., Smooth-on Mfg. Co., 572 Communipaw Ave.
TORRACO, Peter (J'29), 63 Storms Ave.
TRENCH, Wm. H. (J'30), Draftsman, Brunnquell Iron Wks., Inc., West Side Ave. & Carbon Pl.; *for mail*, 128 North St.
WATTERS, Jas. A. (J'35), 893 Pavonia Ave.
WAY, Gordon L. (J'34), 160 Magnolia Ave.
WILSON, Wylie G. ('24), 49 Fisk St.
WRIGHT, T. Eugene ('26), Pres., Thos. Wright Co., Inc., 80 Colden St.
ZULLO, Saml. ('23; '35), Owner, Bergen Jewelry Shop, 757 Bergen Ave.; *for mail*, 1 Astor Pl.

KEARNY, Metropolitan Section

BRESCKA, Rudolph S. ('26; '36), Tool Designer, West. Elec. Co., Inc., Kearny; *for mail*, 306 Manor Ave., Cranford.
CARUTHERS, Elmo, Jr. (J'30), Time Study Engr., West. Elec. Co., Inc., Kearny; *for mail*, 1255 Waverly Pl., Elizabeth.
COBURN, Dwight W. ('32; '35), Engr., Mech. Planning, West. Elec. Co., Inc., Central Ave., Kearny; *for mail*, 714 Lyons Ave., Irvington.
FEENEY, Jos. P. ('28), M. E., Devel. Dept., Congoleum-Nairn, Inc., 195 Belgrove Dr.; *for mail*, 413 Chestnut St.
FOSTER, Newton S. (J'29), M. E., Congoleum-Nairn, Inc., 195 Belgrove Dr.
FRANZ, Erwin E. ('30), M. E., West. Elec. Co., Inc., Kearny; *for mail*, 305 Maple Pl., Cranford.
HODGE, John C. ('31), Section Supvr., West. Elec. Co., Inc., Kearny; *for mail*, 72 Chetwood Terrace, Fanwood.
HOLBROOK, Frank M. ('23), Power & Htg. Engr., Congoleum-Nairn, Inc., Kearny; *for mail*, 10 Lexington St., Newark.
HOLMBERG, Chas. G. ('28), Ch. Tool Designer, West. Elec. Co., Inc., 100 Central Ave., Kearny; *for mail*, 560 N. Chestnut St., Westfield.
INWRIGHT, John A. ('19; '26; '35), Ch. Engr., Kearny Power Sta., Pub. Serv. Elec. & Gas Co.; *for mail*, Stokes Terrace, Moorestown.
IRWIN, J. W. ('32; '35), Engr., Mfg. Capacity Org., West. Elec. Co., Inc., 100 Central Ave., Kearny; *for mail*, 11 Round Top Rd., R. D. 3, Plainfield.
LAPKIN, John D. ('21; '35), Engr., Emark Battery Corp., Belleville Turn Pike, Kearny; *for mail*, 605 Pavonia Ave.
MAYO, Albert R. ('27), Engr., Charge Design, Fed. Shipbldg. & Dry Dock Co., Kearny; *for mail*, P. O. Box 186, Basking Ridge.
MERWIN, Harry H. ('19; '35), Mch. Designer, West. Elec. Co., Inc., 100 Central Ave., Kearny; *for mail*, 254 Springfield Ave., Rutherford.
PROCTOR, Geo. N. ('26; '30; '35), Ch. Engr., Design, Maint., Indus. Engrg., Emark Battery Div., Thos. A. Edison, Inc., Belleville Pike, Kearny; *for mail*, 15 Howard St., Verona.
SAGE, Darrow ('15), Ch. Engr., Kearny Power Sta., Pub. Serv. Elec. & Gas Co., S. Kearny Meadows.
SCHAUB, Herman W. (J'29), Tool Designer, West. Elec. Co., Inc., Kearny, N. J.; *for mail*, 5 W. 63rd St., New York, N. Y.
SHEA, J. R. ('17; '35), Asst. Engr. & Mfr., West. Elec. Co., Inc., 100 Central Ave.
WATERS, D. Vaughn ('17; '21; '27), M. E., West. Elec. Co., Inc., 100 Central Ave., Kearny; *for mail*, 55 Randolph Pl., S. Orange.
WEIDIG, Gustav R. (J'28), Planning Engr., West. Elec. Co., Inc., 100 Central Ave., Kearny; *for mail*, 187 John St., Englewood.
WILD, Donald F. (J'29), Asst. Engr., Repair Planning Dept., West. Elec. Co., Inc., Kearny; *for mail*, 884 S. 17th St., Newark.
YOUNG, G. Alden ('28), Engr., Indus. Devel., West. Elec. Co., Inc., 100 Central Ave.

KENVIL, Metropolitan Section

CAGNONI, Guido James (J'33).

KEYPORT, Metropolitan Section

VELCAMP, Jos. (J'34), 1 Maple Pl.

LAKEWOOD

BOBROVNICHY, B. E. ('27; '35), Route 1, Box 286.

LEONARDO

SCHUERMAN, Emil Lee (J'36), Thompson Ave.

LEONIA, Metropolitan Section

EDEN, Fitzroy L. ('23), 160 Paulin Blvd.
HERR, Willard H. ('23), Mgr., N. Y. Office, Hyd. Press Mfg. Co., Mt. Gilead, Ohio; *for mail*, 198 Moore Ave., Leonia, N. J.
HURST, Saml. A. ('29), 140 Vreeland Ave.
OLIVER, Horace G., Jr. (J'35), Engr., Design, M. W. Kellogg Co., 225 Broadway, New York, N. Y.; *home address*, 108 Grand Ave., Leonia, N. J.
SOLDAN, Henry M. ('35), Ch. Mech. Designer, Elec. Engrg. Dept., Pub. Serv. Elec. & Gas Co., 80 Park Pl., Newark; *for mail*, 195 Hillside Ave., Leonia.

LINDEN, Plainfield Section

CANNON, Jas. P. (J'28), Research Dept., Am. Cyanamid Co., Linden; *for mail*, P. O. Box 411, Elizabeth.
GREENFIELD, Benj. ('18), Research Engr., Combustion Utilities Corp., 60 Wall St., New York, N. Y.; *for mail*, 1900 Linden Ave., Linden, N. J.
ISLES, Fred'k W. ('21; '25), Asst. Supt., Hydrogenation Plant, Bayway Refinery, Stand. Oil Co. of N. J., Linden, N. J.; *for mail*, 846 Hancock St., Brooklyn, N. Y.
JENTSCH, Arthur A. ('28), Ch. Engr., Charge Power, Am. Cyanamid Co., P. O. Box 66, Linden; *for mail*, 337 Sheridan Ave., Roselle Park.
LAWRANCE, Chas. L. ('28), Pres., Lawrance Engrg. & Research Corp., Stiles St.
ZEPHT, Ernest E. ('25; '35), Supvr., Charge Maint., Grasselli Chem. Co., Grasselli St.; *for mail*, 111 Thelma Terrace.

LITTLE FALLS, Metropolitan Section

CARSON, Robt. W. (J'31), Owner, Instrument Specialties Co., 70 Paterson Ave.
CUFF, Harold B. ('26; '35), Engr., Am. Hard Rubber Co., 11 Mercer St., New York, N. Y.; *for mail*, Elm St., Little Falls, N. J.

LIVINGSTON, Metropolitan Section

BURACK, Wm. D. ('31; AM'34), Engr., Condenser Chlorination, Wallace & Tiernan Co., Inc., 11 Mill St., Belleville; *for mail*, 90 Sycamore Ave., Livingston.
RICHARDSON, Marion B. ('24; '35), Educational Adviser, Civilian Conservation Corps, Hdqtrs., 2nd Corps Area, Governors Island, N. Y.; *for mail*, 192 E. Cedar St., Livingston, N. J.

LODI, Metropolitan Section

INGALLS, Chauncey H. ('19), Supt., Millbank Bleachery, Lodi; *for mail*, 44 Ridge Ave., Passaic.
MOOLHUYSEN, Thos. ('23), 95 Hunter St.

LYNDHURST, Metropolitan Section

EHRLICH, M. Wm. ('15; '22; '35), 56 Ridge Rd.
JACK, Geo. ('26; '35), Engr., Charge Design, Prod., J. M. Lehman Co., Inc., New York Ave., Lyndhurst; *for mail*, 428 Sussex Rd., Woodridge.
OHLSON, Carl Arthur (J'33), 379—2nd Ave.
SALVATORE, Roland (J'35), 181 Tontine Ave.
SCHNEIDER, Bernard R. ('27), M. E., Designing, Champlain Corp., Garfield; *for mail*, 621—6th Ave., Lyndhurst.

MAGNOLIA, Philadelphia Section

KAMMERHOFF, Memo ('14), P. O. Box 372, Washington Ave.

MAPLEWOOD, Metropolitan Section

ANNETT, Edw. B. ('14), St. Engr., Pub. Utility Commissioners of N. J., 1060 Broad St., Newark; *for mail*, 35 Oakview Ave., Maplewood.
BRISICK, Jos. C. ('26; '35), Factory Supt., Kroydon Co., Burnett Ave., Maplewood; *for mail*, 100 Ellery Ave., Irvington.
BUSHFIELD, Frank T. (A'22), 25 Bailey Rd.
CYPHERS, James F. ('14; '21), Plant Supt., Charge Mfg., Rockwood & Co., Park & Washington Aves., Brooklyn, N. Y.; *for mail*, 10 Claremont Ave., Maplewood, N. J.
EBERHARDT, U. Seth ('25), V. P., Treas., M. E., Newark Gear Cutting Mch. Co., 69 Prospect St., Newark; *for mail*, 26 Oberlin St., Maplewood.
EVANS, Wm. A. ('13), 24 Woodland Rd.
FOSTER, Chas. C. ('35), 8 Highland Pl.
HAZEN, Silas A. ('21; '35), 40 Ridgewood Terrace.
KEPLER, Donald A. (J'35), Draftsman, Gibbs & Cox, Inc., 21 West St., New York, N. Y.; *for mail*, 30 Maplewood Ave., Maplewood, N. J.
KRUSE, Lowell F. (J'35), Jr. Engr., Design & Maint., Natl. Biscuit Co., 14th St., New York, N. Y.; *for mail*, 5 Park Rd., Maplewood, N. J.
LARSON, Carl B. ('22), 27 Tuscan Rd.
RANKIN, Wm. J. A. ('19), Engr., Lidgerwood Mfg. Co., 775 Lidgerwood Ave., Elizabeth; *for mail*, 28 N. Terrace, Maplewood.
REDDERT, Earl J. ('22; '25; '31), Cons. Engr., Mfg. Div., Colgate-Palmolive-Peet Co., 105 Hudson St., Jersey City; *home address*, 92 Pine St., Maplewood.
ROHRER, Albert L. ('96), Retired; 307 Wyoming Ave.
RUNYON, Malcolm Eagles ('27; '33; '35), Jr. Partner, Runyon & Carey, Cons. Engrs., 31-33 Fulton St., Newark; *for mail*, 14 May Terrace, Maplewood.

MAURER, Metropolitan Section

BOSWELL, Wm. L. (J'22), Engr., Ch. Roofing Div., Tech. Bur., Barber Asphalt Co., Maurer; *for mail*, 41 New Church St., Rahway.
BRANDS, John W. (J'33), Asst. Supt. Power Dept., Am. Smelting & Refining Co., Maurer; *for mail*, 92 Parker Ave., Maplewood.
DiSANTO, Bartel J. (J'26), Plant Engr., Am. Smelting & Refining Co., Maurer; *for mail*, 75 High St., Woodbridge.
GUTHRIE, David F. ('24; '35), M. E. Draftsman, Barber Asphalt Co., Maurer, N. J.; *for mail*, 232 Johnson Ave., Tottenville, S. I., N. Y.
SPENCER, Fred'k A. ('17; '26), Plant Engr., Barber Asphalt Co., Maurer; *for mail*, 86 Grove Ave., Woodbridge.
TOWNSEND, Harry Wilson ('16; '35), M. E., Charge Maint., Federated Metals Corp., State St.

MAYWOOD, Metropolitan Section

TOBLER, Henry, Jr. (J'30), Citro Chem. Co. of Am., Inc., Maywood; *for mail*, 143 Summit Ave., Hackensack.

MERCERVILLE, Philadelphia Section

SONN, Geo. P. ('14; '16; '35), Cons. Engr., 2704 Clarksville Rd.

MERCHANTVILLE, Philadelphia Section

CAMPBELL, Tristram Jos. ('22; '26; '35), Res. Engr., Haynes Corp., 30 Church St., New York, N. Y.; *for mail*, 8 West End Ave., Merchantville, N. J.
FITTS, James L. ('13), Engr., Charge Tests & Design, Warren Webster & Co., 17th & Federal Sts., Camden; *for mail*, 6175 Cedar Ave., Merchantville.

METUCHEN, Plainfield Section

FITZ-GERALD, Gerald ('17; '25), Dist. Rep., Maxon Premix Burner Co., Muncie, Ind.; *for mail*, 67 Oak Ave., Metuchen, N. J.
WILLARD, John W. (J'35), 68 Rector St.

MIDDLESEX BOROUGH, Metropolitan Section

BENDELIUS, Albert (J'34), Shift Suprv., Calco Chem. Co., Inc., Bound Brook; *for mail*, 11 Stout Ave., Middlesex Borough.

MIDLAND PARK, Metropolitan Section

WIEGAND, Francis J. (J'33), 43 Vreeland Ave.

MILLBURN, Metropolitan Section

BRICE, Norman E. ('18; '35), M. E., Permutit Co., 330 W. 42nd St., New York, N. Y.; *for mail*, P. O. Box 14, Millburn, N. J.
HAMBRIGHT, John K. (J'34), 877 Ridgewood Rd.
SWOLAK, Peter A. (J'29), Designer, Fed. Tel. Co., 200 Mt. Pleasant Ave., Newark; *for mail*, 36 Spring St., Millburn.

MILLVILLE, Philadelphia Section

RITCHIE, Paul ('21; '33), Ch. Oper. Engr., Millville Mfg. Co., Columbia Ave.; *for mail*, 572 Columbia Ave.

MONTCLAIR, Metropolitan Section

ALLEN, Frank L. (A'28), Pres., Sales Engr., Frank L. Allen, Inc., 112 Wall Street, New York, N. Y.; *for mail*, 6 Holland Terrace, Montclair, N. J.
BROOKS, J. Ansel ('07; '11), Prof. Indus. Engrg., Newark College of Engrg., 367 High St., Newark; *for mail*, 561 Park St., Montclair.
BUNKER, Wm. Logan ('23,) 52 Ardsley Rd.
CORNELL, Wm. B. ('22), Prof. Mgmt., Chmn. Dept. Mgmt., Sch. of Commerce, N. Y. Univ., Washington Sq., New York, N. Y.; *for mail*, 197 Grove St., Montclair, N. J.

FLINT, B. P. ('94), Retired; c/o Bank of Montclair.
FORSTALL, A. E. ('99), Pub. Utility Cons. Engr., 156 Midland Ave.
GABRIEL, Edwin Z. (J'36), Draftsman, Richardson Scale Co., 668 Van Houton Ave., Clifton; *for mail,* 87 N. Fullerton Ave., Montclair.
GILBRETH, Mrs. Lillian M. ('26), Pres., Gilbreth, Inc., 68 Eagle Rock Way.
HAMILTON, Jean Willard (J'36), Time Study Dept., Weston Elec. Instrument Corp., Frelinghuysen Ave., Newark; *for mail,* 18 Gardiner Pl., Montclair.
HEYDECKE, Clifford W. (J'35), Exper. Test Engr. Wright Aero. Corp., Paterson; *for mail,* 10 Glenridge Pkwy., Montclair.
HOLLOWAY, H. F. ('91), 223 Upper Mountain Ave.
JAEGGLI, H. R. ('30), Sales Engr., Carrier Corp., 180 N. Michigan Ave., Chicago, Ill.; *for mail* 763 Bloomfield Ave., Montclair, N. J.
KEUFFEL, Adolph W. ('30), Asst. Factory Mgr., Keuffel & Esser Co., 300 Adams St., Hoboken; *for mail,* 746 Bloomfield Ave., Montclair.
KLEIN, Rulof ('23), 35 Parkway.
LINTZ, Edgar J. (J'26), 105 N. Mountain Ave.
MACCUBBIN, Alex A. ('27), Cons. Engr., 140 Gordonhurst Ave.
MOODIE, Wm. C. ('21; '23; '35), Wks. Mgr., Calculagraph Co., 306 Sussex St., Harrison; *home address,* 30 Stephen St., Montclair.
ROBE, Geo. A. ('21; '26; '35), 80 Midland Ave.
ROBINSON, Theo. H. (J'24), Pres., Gen. Mgr., Robinson Engrg. Corp., 347—5th Ave., New York, N. Y.; *for mail,* 31 Stevens St., Montclair, N. J.
RYDER, Jas. C. ('18; '35), 345 Grove St.
SCHLACHTER, Carl H. ('06), 12 Crestmont Rd.
SCHWEITZER, Victor (J'24), 5 Willowdale Court.
SCOTT, Campbell ('20), Cons. Engr., 15 Park Row New York, N. Y.; *home address,* 15 Union St., Montclair, N. J.
SHONNARD, Harold W. ('19), 131 Clarewell Ave.
SHULTZ, Jos. A. (J'31), M. E., Charge Maint., Wallace & Tiernan Co., Inc., 11 Mill St., Belleville; *for mail,* 241 N. Mountain Ave. Montclair.
STOVEL, Russell W. ('02; '07), 48 Watchung Ave.
SWAN, John J. ('99; '09), Comptroller, Opera., Pur. & Maint., Barnard College of Columbia Univ., 607 W. 119th St., New York, N. Y.; *for mail,* 296 Claremont Ave., Montclair, N. J.
VROOM, Robt. C. ('29; '35), Ch. Engr., Peabody Engrg. Corp., 580—5th Ave., New York. N. Y.; *for mail,* 16 Vincent Pl., Montclair. N. J.
WEBSTER, Hosea ('83), Life Member for Distinguished Service, '30; Retired; 75 Prospect Ave.
WILSON, A. J. J. A. (J'36), 128 High St.
WISE, Alfred S. ('19; '24; '35), Salesman, Manning, Maxwell & Moore, Inc., 452 Communipaw Ave., Jersey City; *for mail,* 25 Dodd St., Montclair.
YOUNG, PERCY A. ('21; '24), Pneumatic Conveying Specialist, 6 Hawthorne Pl.

MOORESTOWN, Philadelphia Section

HOLLERITH, Herman, Jr. ('19; '28), 737 Golf View Rd.
NICHOLS, Edgar B. ('19; '22), 19 Colonial Ave.

MORRIS PLAINS, Metropolitan Section

FARNY, Major Geo. W. ('01; '07), Craftsman Farms.
MONTGOMERY, Wallace ('23; '24), Cons. Engr., G. Washington Coffee Refining Co., 40 Hanover Ave.

MORRISTOWN, Metropolitan Section

COLVIN, Chas. H. ('16; '25), Colvin Labs., Egbert Hill.
CRISANTE, Alfredo M. (J'34), M. E., Good Rds. Mchy. Corp., Kennett Square, Pa.; *for mail* 21 Evergreen Ave., Morristown, N. J.
GFRORER, Albert H. ('13; '17; '35), R. F. D. 2.

MOUNTAIN LAKES, Metropolitan Section

DOELLING, Hans A. ('28; '35), Ch. Engr., Charge Design, Mfg., U. S. Fire Protection Corp., 1201 Hudson St., Hoboken; *for mail,* 12 Raynold Rd., Mountain Lakes.
HIRSCHBERG, Chas. A. (A'17), Regional Mgr., Sales, Worthington Pump & Mchy. Corp., Harrison; *for mail,* 324 Boulevard, Mountain Lakes.
SMULDERS, Francis, Jr. (J'32), 50 Bellvale Rd.
THOMPSON, O. C. ('10; '15), Babcock & Wilcox Co., New York, N. Y.; *for mail,* 44 Lake Dr., Mountain Lakes, N. J.

NEWARK, Metropolitan Section

AGEE, Howard H. ('20), Rate Engr., Pub. Serv. Elec. & Gas Co., 80 Park Pl.
ALEXOVITS, Thos. M. ('30), 207 Market St.
ALLHUSEN, John (J'30), Test Engr., Pub. Serv. Elec. & Gas Co., Newark, N. J.; *for mail* New Paltz, N. Y.
AXT, Wm. J., Jr. (J'36), 50 Eastern Pkwy.
BAILEY, Miss Ethel H. ('26; '35), M. E., Charge Maint. & Equip., Montclair Pub. Library, Valley Rd. & Church St., Montclair; *for mail,* 444 Summer Ave., Newark.
BARRON, Jacob T. ('19), Gen. Mgr., Elec. Dept. Pub. Serv. Elec. & Gas Co., 80 Park Pl., Newark; *for mail,* 240 Edgar Pl., Elizabeth.
BARTSCH, Arthur G. ('28; '35), Prop., Enterprise Tool & Mfg. Co., Newark; *for mail* Forest Rd., Essex Fells.
BAUER, Edw. C. (J'30), 289 Ridgewood Ave.
BAUHAN, Alex. E. ('14; '17; '35), Supt., Interconnection Engr., Pub. Serv. Elec. & Gas Co. 80 Park Pl.
BEEBE, Robt. O. (A'19), Dir., Essex Co. Vocational Schs., Hall of Records.
BERG, Henry H. ('26), Supt. Plants & Structures Essex Co., High St.
BERGER, Julius G. ('14; '24), Cons. Engr., Indus. Appraiser, 24 Commerce St.
BERGMANN, Chas. ('23; '35), Engr., Charge Tool Design, Westinghouse Elec. & Mfg. Co., 95 Orange St.
BILLINGS, Edw. R. (J'35), Engr. (Serv.), Carrier Corp., 850 Frelinghuysen.
BJORNDAL, Magnus ('33), Ch. Engr., Daven Co., 158 Summit St., Newark; *for mail,* 807 Summit Ave., Jersey City.
BLOCK, Laurence F. (J'24), Traffic Engr., N. J. Bell Tel. Co., 540 Broad St., Newark; *for mail* Box 71, Green Pond.
BODOR, Andrew ('24; '30), Owner, Gen. Mgr., Bodor Engrg. Co., 59 Branford St.
BONIFACE, John B. ('26; '33; '35), Asst. to Engr., Design & Opera., Pub. Serv. Elec. & Gas Co., 80 Park Pl., Newark; *for mail,* 5 Charles Pl., Chatham.
BOSTOCK, R. N. ('36), Partner, Rue & Bostock 605 Broad St., Newark; *for mail,* 225 Inwood Ave., Montclair.
BROWN, Albert Turney ('17), Asst. Engr., Pub. Serv. Elec. & Gas Co., 80 Park Pl.
BRYANT, Percy J. ('16), Ch. Engr., Maint. & Opera., Prudential Ins. Co. of Am., 763 Broad St.
BURCHETT, Walter J. ('20), Ch. Engr., Mech. Art Metal Wks., Aronson Sq., Newark; *for mail,* 48 Hillcrest Terrace, E. Orange.
BURLING, Herbert S. ('13; '24), Marvel Thermostat Div., Universal Tool & Mfg. Co., 226 Jellif Ave., Newark; *for mail,* 308 Tillou Rd., S. Orange.
CADZOW, Murray ('21; '26), M. E., Gilbert & Betelle, Chamber of Commerce Bldg., Newark, N. J.; *for mail,* 8907—107th St., Richmond Hill, L. I., N. Y.
CAMERON, C. Ewen, Jr. ('22; '33), Factory Mgr., Lauter Humana Co., 224 Sussex Ave.
CARBONE, Walter E. (J'35), Engr., Semet-Solvay Engrg. Corp., 40 Rector St., New York, N. Y.; *for mail,* 157 Hunterdon St., Newark, N. J.
CAREY, Paul C. ('30), Mem. Firm, Runyon & Carey, Cons. Engrs., 33 Fulton St.
CARR, Hugh R. ('35), Pres., Mech.-Chem. Engrg. Inc., Raymond Commerce Bldg., Newark; *for mail,* 5 Herning Ave., Cranford.
CARRIER, Willis H. ('05; '12), *A. S. M. E Medallist,* '34; Chmn. Bd., Carrier Corp., 850 Frelinghuysen Ave.
CARVIN, Frank Dana ('30), Prof. M. E., Head Dept., Newark College of Engrg., 367 High St
CHAMBERLAIN, Paul M. ('90; '99), Retired; 201 Milford Ave.
CHAPMAN, Walter W. ('19; '26; '35), Supt. Wm. H. Chapman, 227 Mulberry St., Newark; *for mail,* 10 Park Ave., Bloomfield.
CISLER, Walker L. ('23; '36), Ch. Engr., Marion Generating Sta., Pub. Serv. Elec. & Gas Co. 80 Park Pl.
COATES, Wm. ('28), Ch. Engr., Natl. Newark Bank Bldg., 744 Broad St.; *for mail,* 343 Chadwick Ave.
COLBY, Allan B. (J'28), Wks. Engr., Oxweld Acetylene Co., 646 Frelinghuysen Ave.; *for mail,* Newark Athletic Club.
CROWELL, Henry W. ('12), Globe Indemnity Co., Washington Park, Newark; *for mail,* 25 Woodland Ave., Glen Ridge.
CRUISE, John H. (J'29), 78 Garrison St.
CUMMISKEY, Wm. M. ('14), Designing Engr. Gurney Elev. Co., Inc., 109 W. 64th St., New York, N. Y.; *for mail,* 103 N. 9th St., Newark N. J.
DAVIS, David E. ('22; '26), Asst. Prof. M. E. Newark College of Engrg., 365 High St.
DE FOREST, Edw. T. (J'34), 858 Clinton Ave.
DIAMANT, Sidney ('17), Pres., Gen. Mgr., Diamant Tool & Mfg. Co., Inc., 401 Mulberry St. Newark, N. J.; *for mail,* 155 E. 93rd St., New York, N. Y.
DIETER, Wm. ('17), 67 Renner Ave.
DIGIOVANNI, Mario (J'36), 163 Mt. Prospect Ave.
DOLL, Clyde J. ('27; '28), Devel. Engr., Carrier Corp., 850 Frelinghuysen Ave., Newark; *for mail,* 961 Meredith Ave., Elizabeth.
DOWNS, Edgar S. ('28), Sales Engr., 771 Lake St.
DUNN, Jas. Wm. ('26; '35), Engr., Pub. Serv. Elec. & Gas Co., Rm. 5107, Terminal Bldg., Newark; *for mail,* 37 W. Newell Ave., Rutherford.
DURLAND, Harry S. (J'24), 61 Hinsdale Pl.
EISLER, Chas. ('17; '19), M. E., Prop., Eisler Engrg. Co., 750 S. 13th St.
FAAS, Harry (J'27), Celluloid Co., 290 Ferry St., Newark; *for mail,* 97 Hopkins Pl., Irvington.
FAIRCHILD, Fred'k P. ('15; '26), M. E., Elec. Dept., Pub. Serv. Elec. & Gas Co., Rm. 12326, 80 Park Pl.
FAMIGLIETTI, Anthony A. (J'29), Prod. Mgr., Koebel Wagner Diamond Corp., 144 Orange St., Newark; *for mail,* 5 Reed St., Jersey City.
FAY, Chas. H. ('27), Secy., Treas., John H. Nelles Co., 835 Springfield Ave., Irvington; *for mail* 34 Chancellor Ave., Newark.
FINK, Ferdinand ('27), Supvg. Engr., Mountain Ice Co., 100 Sylvan Ave.
FROST, Vincent M. ('14), M. E., Pub. Serv. Elec. & Gas Co., 80 Park Pl., Newark; *for mail,* 51 Wilcox Ave., E. Orange.
GAREY, Lloyd L. (J'25), Engr., Planning, Elec. Generation Dept., Pub. Serv. Elec. & Gas Co., 80 Park Pl.
GASTON, William Isaac (A'30), 245 N. 6th St.
GAY, Frazer W. ('29), Asst. Engr., Pub. Serv. Elec. & Gas Co., 80 Park Pl.
GOLDEN, Robt. F. ('30), Factory Mgr., Natl. Lock Washer Co., 40 Hermon St., Newark; *for mail.* 67 Fielding Court, S. Orange.
GREENBERG, Benj. (J'33), 165 Johnson Ave.
GUTTMANN, Alfred H. (J'27), Dir. Planning Dept., L. Bamberger & Co., Newark; *for mail,* 5 Osborne Terrace, Maplewood.
HAGERTY, C. C. (J'35), Engr., Charge Boiler Rm., Plastics Div., E. I. du Pont de Nemours & Co., 626 Schuyler Ave., Arlington; *home address,* 780 Broadway, Newark.
HAMILTON, T. Hayden ('27), 47 Lincoln Park.
HELLER, Edgar W. ('23), Pres. Ch. Engr., Lecourtenay Co., 5 Maine St.
HELMSTAEDTER, Geo. O. ('23), Supt., Porete Mfg. Co.; *for mail,* 7 Gillette Pl.
HELMSTAEDTER, Wm. E. ('15), Plant Supt., Celluloid Corp., 290 Ferry St.; *for mail,* 17 Wall St.
HELQUIST, J. E. (J'35), Sales Engrg., Wallace & Tiernan Products Co., 11 Mill St., Belleville; *for mail,* 2 Halleck St., N. Newark.
HERES, Ralph ('31; '35), Plant Supt., Simmons Pipe Bending Wks., 40 Mechanic St., Newark; *for mail,* 251 Winans Ave., Hillside.
HESS, Robt. G. (J'32), Foreman, Charge Meter Assembly, Westinghouse Elec. & Mfg. Co., Plane & Orange Sts., Newark; *for mail,* 120 Rutgers St., Belleville.
HOLLERAN, Dominic J. ('34; '35), Ch. Designer, Natl. Lock Washer Co., 40 Hermon St., Newark; *for mail,* 1 Clermont Ave., Irvington.
HOPE, R. DeVere ('30), Cons. Engr., 850 Frelinghuysen Ave., Newark; *for mail,* P. O. Box 187, Fanwood.
HUNTAR, Felix ('15; '35), Designing Engr., Mch. Shop, Am. Can Co., Hawthorne & Elizabeth Aves., Newark; *for mail,* 1513 Bond St., Hillside.
ILIFF, Wm. L. ('17; '25), Mgr., East. Sales Div., Hyatt Roller Bearing Div., Gen. Motors Co., Box 476.
JANSSON, John H. ('24; '35), Supvr. Engr., Turbine Engrg. Dept., Gen. Elec. Co., 744 Broad St., Newark; *for mail,* 548—34th St., N. Bergen.
JONES, Walter F. ('20; '35), Engr., Charge Refrig., Carrier Corp., 850 Frelinghuysen Ave.
JULLIEN, Auguste ('28; '35), Engrg. Dept., Combustion Engrg. Co., Inc., 200 Madison Ave., New York, N. Y.; *for mail,* 745 S. 10th St., Newark, N. J.
KABIS, Chas. W. (J'35), Jr. Engr., Walter Kidde & Co., Inc., Bloomfield; *for mail,* 15 Cedar Ave., Newark.
KEENE, J. A. (J'27), Engr., Loads, Pub. Serv. Elec. & Gas Co., 80 Park Pl.
KENNEDY, Paul S. ('26), V. P., Charge Devel., Murphy Varnish Co., 224 McWhorter St.
KETCHUM, Samuel ('08; '17), Devel. Dept., Carrier Corp., 750 Frelinghuysen Ave., Newark; *for mail,* 16 Appleton Pl., Glen Ridge.
KLUESENER, Hugo H. ('34; '35), Mch. Design. Am. Can Co.; *for mail,* 206 Leslie St.
KRICHBAUM, Wm. F. ('29), Pres., Foster Engrg. Co., Newark; *for mail,* 14 Park-View Dr., Millburn.
KUSHMAN, Jos. C. ('29; '35), Mch. Design & Devel. Engr., Hyatt Roller Bearing Div., Gen. Motors Corp., Harrison; *home address,* 296 Weequahic Ave., Newark.
KUTTLER, John B. ('28; '34), Asst. Ch. Engr., Supervision Design, Oper. & Maint., Prudential Ins. Co. of Am., 763 Broad St., Newark; *for mail,* 420 Spruce St., Roselle Park.

LA MOTTE, Wm. R. ('26), Supt., Essex Generating Sta., Public Serv. Elec. & Gas Co., 155 Raymond Blvd.
LAWSON, Jas. T. ('15; '19), Asst. to Gen. Supt. of Generation, Elec. Dept., Pub. Serv. Elec. & Gas Co., 80 Park Pl.
LEVERING, W. C. (J'30), Draftsman, Am. Can Co., Elizabeth & Hawthorne Aves., Newark; *for mail*, 2017 Kay Ave., Union.
LEVY, Harry (J'33), Charge Prod., Paper House of N. J., 98 Branford Pl.; *for mail*, 18 Jacob St.
LISTER, Alfred ('13), Mech. Supt., Clark Thread Co., 260 Ogden St.
LOOMIS, Evarts G. ('13), M. E., Evarts G. Loomis Co., 126 S. 14th St.
LOUTREL, Cyrus H. ('12; '16; '35), Pres., Natl. Lock Washer Co., 40 Hermon St.
LUSK, Sherman W. ('30; '35), Power Engr., Prudential Ins. Co. of Am., 763 Broad St.
MACNABB, Clifton ('17; '26), Cost Estimating Engr., Pub. Serv. Elec. & Gas Co., 80 Park Place, Newark; *for mail*, 46 Burnett St., Maplewood.
MAIER, Wm. H. (J'35), Checker, Time Study, Swift & Co., 1215 Harrison Ave., Harrison; *for mail*, 60 Taylor St., Newark.
MARKOVITS, Theo. ('32), Dir. of Research, Hoffman Beverage Co., 402 Grove St., Newark; *for mail*, 302 Richmond Ave., S. Orange.
McLELLAND, Austen (J'32), Engr., Charge Time Study, Savory Inc., 591 Ferry St.; *for mail*, 110 Montrose St.
MEMORY, N. H. ('30), Asst. to V. P. & Ch. Engr., Isbell-Porter Co., 46 Bridge St., Newark; *for mail*, 85 Cedar St., Maplewood.
MEYER, Jos. A. ('23), Pres., Gen. Mgr., Meyer Engrg. Co., 427 Peshine Ave.
MEYER, Peter ('20; '32), Pres., Treas., Boeger-Meyer Mch. & Tool Co.; *for mail*, 21 Voorhees St.
MIERKE, Fred'k Wm. ('29; '32; '35), Engr., Travelers Indemnity Co., 60 Park Pl.; *for mail*, 191 S. 7th St.
MUHLETHALER, Richard, Jr. (J'32), 269 Chadwick Ave.
MURPHY, Geo. F. ('26; '35), Designing Engr., Linde Air Products Co., 686 Frelinghuysen Ave.
MURPHY, Wm. J. ('27), Constr. Supt., Pub. Serv. Elec. & Gas Co., 80 Park Pl., Newark; *for mail*, 233 Sherman Ave., Glen Ridge.
NELSON, Wm. Andrew ('24), Sales Engr., Ingersoll-Rand Co., 899 Frelinghuysen Ave.
NEWELL, Thos. A. (J'34), Indus. Engr., E. I. du Pont de Nemours & Co.
NORDSTROM, Elof ('28), M. E., Hoffman Beverage Co., 402 Grove St., Newark; *for mail*, 12 Summit St., E. Orange.
OTTERBEIN, Mark E. (J'35), 274 Johnson Ave.
OVERWATER, John (J'30), 37 Lehigh Ave.
PARKER, Chas. E. (J'29), Test Engr., Pub. Serv. Elec. & Gas Co., Essex Generating Sta., Raymond Blvd.
PASMAN, Jas. S. ('22; '30), V. P., Sandvik Conveyor Mfg. Co., 21 Amsterdam St., Newark; *for mail*, 62 Salter Pl., Maplewood.
PAUSIN, Hugo R. ('16; '17), Pres., Gen. Mgr., Pausin Engrg. Co., 727 Frelinghuysen Ave., Newark; *for mail*, 48 Plymouth Ave., Maplewood.
PENN, Marion ('21; '30), Gen. Mgr., Elec. Dept., Pub. Serv. Elec. & Gas Co., 80 Park Pl. Newark; *for mail*, 333 Beech Spring Rd., S. Orange.
PETERSEN, Alfred V. (J'27), Tool & Die Designer. Am. Can Co., Elizabeth & Hawthorne Aves. Newark; *for mail*, 68 Earl St., Union.
PHELPS, Fred'k A. ('92), Engr. & Arch., 21 Fulton St.
PIPEROUX, Rene Pierre ('36), Celluloid Corp., 290 Ferry St.
POPE, Clarence J. (J'14), Cons. Engr., Public Utility Comm., 1060 Broad St., Newark; *for mail*, 399 Tremont Pl., Orange.
PORTER, Harry W. ('20; '35), Pres., H. W. Porter & Co., Inc., 825 Frelinghuysen Ave.
POWELL, Oliver I. (J'34), Designing Engr., Hoffman Beverage Co., 400 Grove St., Newark; *for mail*, 40 Lenox Ave., E. Orange.
PRANER, Jos. A. (J'32), M. E., Wage Incentives. Leiman Bros., 157 Christie St., Newark; *for mail*, 327 Tremont Ave., E. Orange.
PRESBREY, Otis F. ('23; '35), Lehman Mar. Engrg. Co., 972 Broad St., Newark, N. J.; *for mail*, 1156 E. 38th St., Brooklyn, N. Y.
PRIOR, John Edw. (J'35), Final Tester, Westinghouse Elec. & Mfg. Co., Newark; *for mail*, 41 Alexander Ave., Kearny.
PURDY, Howard Edw. (J'31), Instr. M. E. Lab., Newark College of Engrg., 367 High St., Newark; *for mail*, 1056 Kensington Terrace, Union.
RANKEN, H. B. ('29; '31), Asst. State Survey, N. J. Geodetic Control Survey, 17-19 William St., Newark; *for mail*, 401 Orchard St., Cranford.
RATHMAN, Gilbert ('25), Engr., Quimby Pump Co., Inc., 340 Thomas St.
RAUSCH, Victor H. ('31), Supt., D. S. Plumb. Co., Inc., 73-77 Norfold St., Newark; *for mail*, 14 Coolidge Rd., Maplewood.
REDFIELD, Clarke (J'32), Installation & Serv. Mgr., Blocker Air Conditioning Corp., Newark; *for mail*, 64 Ettrick Terrace, Rutherford.
RICHARDSON, George P. ('01; '17), Asst. Engr., Isbell-Porter Co., 46 Bridge St., Newark; *for mail*, 441 Baldwin Rd., Maplewood.
ROCKEFELLER, Jos. A. (J'26), Indus. Fuel Rep., Pub. Serv. Elec. & Gas Co., 80 Park Pl.
ROCKWELL, Harvey P., Jr. (J'34), Sales Engr., Photronic Div., Weston Elec. Instrument Corp., Frelinghuysen Ave.; *for mail*, 1202 Essex House.
ROSENTHAL, Jos. A. (J'29), Ch., M. E. Dept. United Color & Pigment Co., McClellan St.; *for mail*, 62 Ingraham Pl.
RUE, Harold E. ('23; '27), Cons. Engr., Rue & Bostock, 605 Broad St.
RUNYON, Fred'k O. ('09), Cons. Engr., Mem. Firm. Runyon & Carey, Cons. Engrs., 31-33 Fulton St., Newark; *for mail*, 26 Hickory Dr., Maplewood.
RUSSELL, Floyd L. ('23), Constr. Engr., Pub. Serv. Elec. & Gas Co., 80 Park Pl.
SALTZMAN, Auguste Louis, Jr. (J'22), Salesman, Naphthas & Solvents, Stand. Oil Co. of N. J., 185 Washington St., Newark; *for mail*, 200 Sterling Dr., Orange.
SANFILLIPPO, S. E. (J'34), Engrg. Draftsman, United Shipyards, Inc., Mariner's Harbor, S. I., N. Y.; *for mail*, 18 Newark St., Newark, N. J.
SCHER, Geo. ('25), Pres., Gen. Mgr., Weber & Scher Mfg., Co., Inc., 263 Sussex Ave.
SCHERER, Herman A. G. ('19; '22; '27), M. E., Ivers-Lee Co., 215 Central Ave., Newark; *for mail*, 71 Pine Grove Ave., Summit.
SCHWEIZER, Paul Eugene ('25; '34), Asst. Prof. M. E., Newark College of Engrg., 367 High St., Newark; *for mail*, 14 Stewart Ave., Arlington.
SERRELL, John J. ('17; '20), Partner, Smith & Serrell, 20 Washington Pl.
SHAW, Herbert G. ('16; '25; '35), Instr., Designer, Weston Elec. Instrument Corp., Newark; *for mail*, 304 Chestnut St., Roselle Park.
SIDSERF, Edw. H. (J'34), 906 DeGraw Ave.
SIGNORELLI, Alfred (J'36), Designing Engr. Welding Apparatus, Linde Air Products Co., 684 Frelinghuysen Ave.; *for mail*, 728 Hunterdon St.
SMITH, Eastman ('22; '27; '35), Asst. Prof. Physics, Newark College of Engrg., Newark; *for mail*, 63 Hillside Ave., Chatham.
SNYDER, Harry E. ('22), Asst. Gen. Mgr., Mfg. Div., Carrier Corp., 850 Frelinghuysen Ave.
SOULIS, Harold A. ('25), Ch. Engr., Trucktor Corp., 156 Wilson Ave.
SUDA, Gerard (J'35), Jr. Engr., Design, Mfr. Trucktor Corp., 156 Wilson Ave., Newark, N. J.; *for mail*, 20-46—29th St., Astoria, L. I., N. Y.
TALCOTT, Agnew A. (J'32), Sales, Technician on Solvents, Am. Oil & Supply Co., 238 Wilson Ave., Newark, N. J.; *for mail*, 117 E. 10th St., New York, N. Y.
THOMSON, A. MacFarlane ('26; '35), Bldg. Supt. N. J. Bell Tel. Co., 540 Broad St.; *for mail* 483 Parker St.
THOMSON, J. Stewart (J'01), Apt. 12, 3 Oxford St.
TOMPKINS, Sherman A. (J'35), Research Engr., Carrier Corp., 750 Frelinghuysen Ave., Newark N. J.; *for mail*, Berne, N. Y.
TRAGER, Leon ('24), Engr., Charge Design. Worthington-Gamon Meter Co., South St.; *for mail*, 133 Osborne Terrace.
TREIBER, Kenneth L. (J'32), Designer, Lecourtenay Co., 5 Main St.
VALENZA, Noel Chas. (J'32), Map Draftsman. Bur. of Streets, City of Newark, City Hall; *for mail*, 12 Searing St.
VASSELLI, Anthony J. ('20; '35), 85 Heddon Terrace.
VELARDO, Anthony J. (J'36), 281 Adams St.
VEXLER, Leonard (J'31), Grad. Student., Poly. Inst. of Bklyn., Brooklyn, N. Y.; *for mail* 70 Lyons Ave., Newark, N. J.
VLAHAKES, John L. (J'35), Engr., Reconnaissance, N. J. Geodetic Control Survey, 17-19 William St.; *for mail*, 34 Stirling St.
VOGELBACH, Oscar ('32), Guilbert & Betelle. Newark; *for mail*, 23 William St., N. Arlington.
VON FABRICE, R. ('22), Designing Engr., Pub. Serv. Elec. & Gas Co., 80 Park Pl.
WAGNER, Clark A. (J'30), Devel. Engr., Intermetal Corp., Newark, N. J.; *for mail*, 8514—114th St., Richmond Hill, L. I., N. Y.
WALDECK, Lester E. (J'34), Sales & Serv. Engr., Blue Coal Corp., 372 Central Ave., Newark, N. J.; *for mail*, 82 N. Allen St., Albany, N. Y.
WALLER, P. F. W. (J'29), 79—3rd Ave.
WHEELER, Frank I., Jr. ('21; '35), Plant Engr., Tiffany & Co., Forest Hill, Newark; *for mail*, 9 Ardsley Rd., Glen Ridge.
WHITE, Geo. Clifford ('19; '35), Office Mgr., Burnetts Inc., 217 Plane St., Newark; *for mail*, 382 Chapman St., Irvington.
WHITE, J. W. Huyler ('17; '21), Mortgage Loan Dept., Serv. Div., Prudential Ins. Co. of Am., 763 Broad St.; *for mail*, 32 Peck Ave.
WILKINSON, Geo. D., Jr. (J'33), *Charles T. Main Award*, '33; Instr., Indus. Engrg., Newark College of Engrg., 367 High St.
WILLIAMSON, Geo. L. (J'32), Sales Engr., H. A. Wilson Co., 105 Chestnut St.
WILLIAMSON, Wm. S. (A'26), Supt. Bldgs., Prudential Ins. Co. of Am., 763 Broad St.
WOTTRICH, Herbert (J'23), Managerial Assoc. Elec. Dept., Pub. Serv. Elec. & Gas Co., 80 Park Pl.
WRIGHT, Frederic E. ('22), Head, Sales Dept. Internatl. Oxygen Co., 795 Frelinghuysen Ave., Newark, N. J.; *for mail*, 93 N. Parsons Blvd., Flushing, L. I., N. Y.
ZIMMERMAN, John H. ('32), Devel. Engr., Charge Lab., Linde Air Products Co., 686 Frelinghuysen Ave.

NEW BRUNSWICK, Metropolitan Section

BACHA, Chas. P. (J'35), *Postgraduate Student Award*, '35; Test Engr., Internatl. Motor Co., Jersey Ave., New Brunswick; *for mail*, 91 Amboy Ave., Metuchen.
BAILEY, Neil P. ('24; '30; '35), Prof., Head Mech. Engrg. Dept., Rutgers Univ.
CASE, Lynn B. (J'18), Gen. Mgr., John Waldron Corp.; *for mail*, Riverview Apt.
DEMOUGEOT, Geo. Maurice ('27; '35), Plant Mgr., Carrier Corp., Jersey Ave., New Brunswick; *for mail*, 107 N. 5th Ave., Highland Park.
GAUM, Carl G. ('27), Prof., Univ. Extension Div., Rutgers Univ.
GOETZE, Fred'k ('24; '35), Pres., Goetze Gasket & Packing Co., Inc., Allen Ave.
HECK, Robt. C. H. ('06), *Life Member for Distinguished Service*, '22; Research Prof. M. E., Rutgers Univ.; *for mail*, 35 College Ave.
HOLLAND, Ubert C. ('24; '35), Asst. Prof. Mech. Engrg., Rutgers Univ.
KOENIG, F. Emil ('25; '35), Designing Engr., John Waldron Corp., New Brunswick; *for mail* 22 Cliffwood Place, Metuchen.
MARIN, Jos. ('36), Asst. Prof. Engrg. Matls., Rutgers Univ.
MEHRHOF, Floyd E. ('19; '24; '35), Asst. Ord. Engr., Ord. Dept., U. S. A.; *for mail*, 217 E. 3rd Ave.
PRAY, Lawrence C. (J'35), Draftsman, Asst. to Ch. Engr., Ransome Concrete Mchy. Co. Dunellen; *for mail*, 216 S. 1st Ave., New Brunswick.
SPRUITENBURG, M. J. (J'30), 217 George St.
STAMP, Jas. W. H. (J'32), Johnson & Johnson Inc., New Brunswick, N. J.; *for mail*, 28 Fuller Pl., Brooklyn, N. Y.
TEICHMAN, Wm. Alex. (J'35), Jr. Engr., Constr. & Design, Hercules Powder Co., Inc., Parlin; *for mail*, 238 Raritan Ave., New Brunswick.
TROGER, Henry H., Jr. (J'27), Asst. Plant Engr., Fed. Shipbldg. & Dry Dock Co., Lincoln Highway, Kearny; *home address*, R. F. D. 1, New Brunswick.
VEBER, Clinton P. (J'33), 15 Hardenburgh St.
WALDRON, Jerome H. (J'28), Supvr. & Estimator, Plumbing & Htg., Highland Park Bldg. Co., Cleveland Ave.; *for mail*, R. R. 2, Box 8 H.
WALDRON, Wm. H. ('21), V. P., John Waldron Corp.; *for mail*, Bishop Pl.
WERTHEIM, Ferd E. ('29; '35), c/o Y. M. C. A., 9 Livingston Ave.

NEW MILFORD, Metropolitan Section

REINKE, Chas. C. ('22; '26), Estimator, R. Hoe & Co., New York, N. Y.; *for mail*, Prospect Ave. & Cleveland St., New Milford, N. J.

NORTH ARLINGTON, Metropolitan Section

EMERY, Hugh (J'33), 20 Morgan Pl.

NORTH BERGEN, Metropolitan Section

CINCOTTA, Jos. J. (J'34), 415—27th St.
FINSTER, Geo. C. (J'36), Cadet Engr., Natl. Biscuit Co., 449 W. 14th St., New York, N. Y.; *for mail*, 551—34th St., N. Bergen, N. J.

NORTH HALEDON, Metropolitan Section

BOCCHIO, R. R. (J'36), Manchester Ave.

NORTH PLAINFIELD, Plainfield Section

APPLEGATE, Wm. A. ('36), Mech. Draftsman, Research Corp., Main St., Bound Brook; *for mail*, 159 Westervelt Ave., N. Plainfield.

NUTLEY, Metropolitan Section

ASHWORTH, J. Vernon (J'36), Student, Factory Training Course, Hamilton Watch Co., Columbia Ave., Lancaster, Pa.; *for mail,* 32 Coeyman Ave., Nutley, N. J.
BACON, Benj. S. ('35; '35), Plant Supt., Consltd. Products Co., Inc., 335 Doremus Ave., Newark; *for mail,* 227 Vreeland Ave., Nutley.
COOKSON, Leonard T. ('31), Supvr., Charge Prod., Wallace & Tiernan Products Co., 11 Mill St., Belleville; *for mail,* 356 Prospect St., Nutley.
IRION, Wm. ('26; '35), M. E., Geo. LaMonte & Son, 299 Kingsland Rd.; *for mail,* 682 Bloomfield Ave.
KEAY, Arthur E. ('34; '35), Designer, Oil Pipe Line, Texas Oil Co., 135 E. 40th St., New York, N. Y.; *for mail,* 97 Myrtle Ave., Nutley, N. J.
MEYERSTEIN, Anthony M. (J'27), Ch. Engr., Rosoff Bros., 66 Court St., Brooklyn, N. Y.; *for mail,* 79 Elm Pl., Nutley, N. J.
NORTHRUP, Francis B. ('05; '16), 58 Raymond Ave.

OAKHURST, Metropolitan Section

WOOD, John Lindsay (J'25), 394 Roosevelt Ave.

OAKLYN, Philadelphia Section

TURNER, M. C. ('27; '35), 9 E. Hadden Ave.

ORADELL, Metropolitan Section

HUGLI, Wilfred C., Jr. (J'36), 700 Orchard St.

ORANGE, Metropolitan Section

ABRAMS, Herbert T. ('01), 218 Cleveland St.
BABCOCK, Wm. S., Jr. (J'33), Jr. Engr., Prod. Engrg. Dept., Monroe Calculating Mch. Co., Mitchell St.; *for mail,* 733 Mosswood Ave.
BRITTEN, Clarence R. ('29), Plant Mgr., Monroe Calculating Mch. Co., 555 Mitchell St.
DURAND, Nelson C. ('89), V. P., Thos. A. Edison, Inc., Orange; *for mail,* 116 Prospect St., E. Orange.
FISHER, Wm. W. ('10; '21; '21), Ch. Engr., Monroe Calculating Mch. Co., 555 Mitchell St.
HUTCHISON, Fred P. (J'18), 125 Main St.
MATTHEWS, Reginald G. ('34; '35), 377 Hillside Ave.
MOMBERGER, Wm. J. ('21), Supvg. Engr., Orange Memorial Hospital, Essex Ave.
MORRIS, Jerome D. (J'35), 46 High St.
NOFSINGER, Lewis E. ('29; '35), Apt. 37, 641 Lincoln Ave.
SALTZMAN, Auguste Leopold ('08), Cons. Engr., 731 S. Centre St.
WILLERTON, Gustav E. ('27; '35), Mch. Designer, Internatl. Business Mchs. Corp., 310 Main St.; *for mail,* 18 Cleveland St.

PALISADES PARK, Metropolitan Section

BAILEY, Daniel Robt. (J'33), Engr., Fidelity & Casualty Co. of N. Y., 80 Maiden Lane, New York, N. Y.; *for mail,* 1 E. Harriet Ave., Palisades Park, N. J.
HALL, Herbert H. ('24; '35), Devel. Engr., Aluminum Co. of Am., Edgewater; *for mail,* 27 Henry Ave., Palisades Park.
LUDWIG, Alwin (J'25), 30 W. Harriet Ave.
SMITH, Allen E. (J'30), Automotive Engr., Socony-Vacuum Oil Co., Inc., 412 Greenpoint Ave., Brooklyn, N. Y.; *for mail,* 1 W. Palisades Blvd., Palisades Park, N. J.

PARLIN, Metropolitan Section

De LUCA, Everett (J'36), M. E., Cadet, Maint., Hercules Powder Co., Parlin; *for mail,* 197 Main St., South River.

PASSAIC, Metropolitan Section

ALBANESE, Michael (J'29), 31 Park Pl.
BINDER, Adolpf R. (J'32), Tech. Aide, U. S. Rubber Co., Inc., Passaic St., Passaic; *for mail,* 266 Santiago Ave., Rutherford.
BOHN, Louis G. ('29; '35; '35), M. E., Manhattan Rubber Co., Passaic; *for mail,* 408—33rd St., N. Bergen.
CIZEK, J. J. (A'30), 73 Penington Ave.
CLOCK, Ernest Edward ('17; '20), Cons. Engr., 100 Park Pl.
COBB, Willard Halsey (J'12), Gen. Factory Mgr., U. S. Rubber Products, Inc., 1 Market St.
DUCHNOWSKI, Henry E. (J'36), Draftsman, Rutherford Mchy. Co., Central Ave., E. Rutherford; *for mail,* 39 Van Buren St., Passaic.
FIALA, Sigmund N. (J'25), 63 Union Ave.
JEWETT, Wm. R. (J'36), 87 Lincoln St.
KOWALSKI, Edward (J'33), 18 Quincy St.
LINDENMEYR, Carl E. (J'33), Indus. Engr., Forstmann Woolen Co., Passaic; *for mail,* 605 Valley Rd., Upper Montclair.
NEEDHAM, Harry Sydney ('27; '33; '35), Draftsman-Designer, Hyatt Roller Bearing Div., Gen. Motors Co., Harrison; *for mail,* 46 Van Houten Ave., Passaic.
OLSSON, Chas. D. (J'33), 15 Dakota St.
OWEN, Chas. D. ('36), Ch. Engr. & M. E., Charge Maint., Passaic Pioneer Properties, Inc., 35—8th St.; *for mail,* P. O. Box 632.
PERKINS, Wilder E. (J'25), M. E., Asst. Dept. Mgr., Manhattan Rubber Mfg. Co., Div. of Raybestos-Manhattan, Inc., Willet St., Passaic; *for mail,* 191 Luddington Ave., Clifton.
PFEIL, Walter George ('21; '35), Jr. Engr., N. Y. Edison Co., 4 Irving Pl., New York, N. Y.; *for mail,* 105 Meade Ave., Passaic, N. J.
RAHM, Hans E. (J'31), 105 Gregory Ave.
UEHLING, F. F. ('18), Pres. & Combustion Engr., Uehling Instrument Co., 473 Getty Ave., Paterson & 86 Park Ave.
von ELTZ, K. ('23), Ch. Engr., Botany Worsted Mills; *for mail,* 121 Dayton Ave.
WAECHTER, Wm. B. ('30; '35), 55 Park Ave.
WARR, Wm. ('15), M. E., Manhattan Rubber Mfg. Co., Div. of Raybestos-Manhattan, Inc., Passaic; *for mail,* 17 Webster Pl., E. Orange.
WIGGLESWORTH, Walter F. ('27; '35), M. E., Charge Maint., Opera., United Piece Dye Wks., Goffle & Wagavan Rd., Hawthorne; *for mail,* 76 Amsterdam Ave., Passaic.

PATERSON, Metropolitan Section

BEALL, Almon L. ('30), Research Engr., Wright Aero. Corp., 1121 E. 19th St., Paterson; *for mail,* 456 Morse Ave., Ridgefield.
CERVINO, Michael P. (J'35), 34 Cross St.
ELLIOTT, Wm., Jr. ('15; '35), Secy., Treas., Leslie & Elliott Co., E. Railway & Iowa Ave.
ENNIS, Herbert V. ('10; '21), Prod. Dept., Am. Car & Fdy. Co., 30 Church St., New York, N. Y.; *for mail,* 661 E. 26th St., Paterson, N. J.
ENNIS, Jos. B. ('09), V. P., Engrg., Am. Loco. Co., 30 Church St., New York, N. Y.; *for mail,* 9 Pope Rd., Paterson, N. J.
FERGUSON, John W. ('91), Pres., John W. Ferguson Co., Inc., 152 Market St.
GAGG, R. F. ('23; '34), Asst. Ch. Engr., Wright Aero. Corp.
GILLEN, Geo. M. ('24), 33—18th Ave.
GILLIAM, Howard H. ('24; '35), 372—10th Ave.
GORDON, M. B. ('20; '25), V. P. & Gen. Mgr., Wright Aero. Corp., 1120 E. 19th St.
GRADY, Jas. J. (J'36), Machinist, Watson-Flagg Mch. Co., 845 E. 25th St.; *for mail,* 667 E. 29th St.
GUBELMAN, F. J. (A'95), Pres., New Era Mfg. Co., 375—11th Ave.
HANDLER, Henry (J'36), Jr. Engr., U. S. Govt., 300 E. 18th St., Paterson; *for mail,* 20 W. Van Ness Ave., Rutherford.
HIGBIE, Vinton ('31; '35), Field Engr., Wright Aero. Corp.; *for mail,* 365—12th Ave.
KITTREDGE, John M. (J'35), Test Observer, Wright Aero. Corp.; *for mail,* 849 E. 27th St.
LOSSON, Wesley L. (J'28), Test Engr., Wright Aero. Corp., 238 Lewis St.
LUNDQUIST, W. G. (J'29), Eng. Dept., Wright Aero. Corp., Paterson; *for mail,* 231 Hamilton Ave., Glen Rock.
MACKAY, Geo. W. ('26; '34; '35), Prod. & Matl. Control, Wright Aero. Corp., 238 Lewis St., Paterson; *for mail,* 8 Park Terrace, Upper Montclair.
MARSILIO, Bruno (J'29), Metallurgical Lab. Asst., Wright Aero. Corp., Paterson; *for mail,* 516—29th St., Union City.
McDONALD, John N. (J'36), Test Observer, Wright Aero. Corp.; *for mail,* 402—15th Ave.
MILSON, Thos. H. ('03), Hamilton Club.
PEARSON, Fred A. (J'32), Checker, Wright Aero. Corp., Paterson; *for mail,* 313 Harding Ave., Clifton.
PRYOR, F. L. ('00; '06), Cons. Engr., 5 Colt St.
REIMERS, Bernhardt F. ('25; '31), Div. Indus. Fuel Rep., Pub. Serv. Elec. & Gas Co., Box 1459, 188 Ellison St.
ROYLE, Vernon E. ('05; '17), M. E., John Royle & Sons; *for mail,* 399—15th Ave.
YOUNG, Wm. H., Jr. ('26; '35), Student, Pat. Law Office, 140 Market St.

PAULSBORO, Philadelphia Section

HAMMELL, Reeve H. ('24; '31; '35), M. E. in Research, Socony-Vacuum Oil Co., Inc.
MOCHEL, Myron G. (J'30), Research Engr., Lub., Socony-Vacuum Oil Co., Inc., Paulsboro; *for mail,* 221 Lexington Ave., Pitman.
SHERMAN, Wm. T. ('32), Power Engr., Design, Opera. & Maint. of Utilities, Socony-Vacuum Oil Co., Inc., Paulsboro; *for mail,* 249 S. Warner St., Woodbury.
SIBSON, Wm. A. ('24; '31; '35), Acting Ch. Engr., Socony-Vacuum Oil Co., Inc., Paulsboro; *for mail,* Woodbury Court Apts., 11A, Woodbury.
STAPLES, Chas. W. ('24; '32; '35), Research Engr., Socony-Vacuum Oil Co., Inc., Paulsboro; *for mail,* 502 Pitman Ave., Pitman.
STEWART, J. P. ('30), Research & Devel. Div., Socony-Vacuum Oil Co., Inc.
WEBER, Albert M. (J'33), Lab. Inspr., Socony-Vacuum Oil Co., Inc., Paulsboro; *for mail,* 103 E. Maple St., Wenonah.

PEAPACK, Metropolitan Section

SPRAGUE, Russell (J'36).

PEDRICKTOWN, Philadelphia Section

BURGEY, Saml. S. ('35), Capt., Ord. Dept. U. S. A., Asst. to C. O., Del. Ord. Depot.

PENNS GROVE, Philadelphia Section

MERRY, Harold G. (J'28), 305 State St.
MICALLEF, Jos. M. ('24; '35), Power Supvr., E. I. du Pont de Nemours & Co., Smokeless Powder Dept., Lock Box 1, Penns Grove; *for mail,* 171 Division St., Carneys Point.

PERTH AMBOY, Metropolitan Section

GUNDERSON, G. Chas. ('26), Engr., Charge Power, Bakelite Corp., Bound Brook; *home address,* 72 State St., Perth Amboy.
HAWKE, Clarence E. ('27), Sales Mgr., Refractory Div., Carborundum Co.
HEIN, Edwin A. (J'35), Asst. to Plant Engr., Am. Smelting & Refining Co.
JOHNSON, Boyd M. (J'22), Ch. Engr., Engrg. Dept., Carborundum Co.
KEMP, Lorin W. ('29), Mgr., Internatl. Smelting & Refining Co., Raritan Copper Wks.
La RUE, Allan B. (J'35), 65 State St.
THOMPSON, Robt. (J'34), 70 High St.

PHILLIPSBURG, Anthracite-Lehigh Valley Section

BAILEY, Chas. R. (J'36), Refrigeration Engrg. Dept., Ingersoll-Rand Co.
BURNS, Rodney C. (J'31), Engr., Turbo Blower Dept., Ingersoll-Rand Co.; *for mail,* 205 Summit Ave.
CSISEK, John J. ('28; '33; '35), Mfg. Supvr. of Motor Pumps, Ingersoll-Rand Co., Phillipsburg; *for mail,* W. Portal.
FRITTS, Stewart S. (J'33), Physical Chemist, Edison Cement Corp., Stewartsville; *for mail,* 127 Bullman St., Phillipsburg.
GREENAWALT, Russell F. (J'34), Test Engr., Ingersoll-Rand Co.; *for mail,* 192 Lincoln Rd.
HAMLIN, Frederic (J'33), Prod. Engr., Ingersoll-Rand Co., Phillipsburg; *for mail,* Washington.
HINTON, Chas. L., Jr. (J'30), Jr. Engr., Condenser Dept., Ingersoll-Rand Co.
HORNSCHUCH, Hanns (J'30), Pump Engr., Cameron Pump Div., Ingersoll-Rand Co., Phillipsburg, N. J.; *for mail,* 33 S. 12th St., Easton, Pa.
JAMESON, John A. (J'34), Serv. Man., Ingersoll-Rand Co.; *for mail,* 346 Bates St.
KIRGAN, John F. ('19; '21; '27), Engr., Charge Refrig. Engrg. Dept., Ingersoll-Rand Co.
MATTHEWS, Wm. E. ('28), Foreman, Steam Turbine, Compressors, Diesel Engs., Ingersoll-Rand Co., Phillipsburg; *for mail,* 9 Taylor St., Washington.
McBRIDE, W. J. ('20), Centrifugal Air Compressors, Ingersoll-Rand Co.
McCONAGHY, Jas. W. (J'30), Test Engr., Ingersoll-Rand Co.; *for mail,* 119 Henderson St.
McHUGH, Anthony L. ('26), Ingersoll-Rand Co.
MILLER, Ralph ('19; '35), Ch. Engr., Diesel Eng. Dept., Ingersoll-Rand Co.
ROUCH, Ernest A. ('24; '34; '35), Checker, Engrg. Dept. Cameron Pump Div., Ingersoll-Rand Co., Phillipsburg, N. J.; *for mail,* R. D. 4, Bangor, Pa.
RUTTER, John A. ('19), Supt., Cameron Pump Div., Ingersoll-Rand Co.
SEYFARTH, Francis (J'36), Indus. Student, Ingersoll-Rand Co.; *for mail,* 285 Bates St.
UPHAM, Wendell K. (J'36), Engr., Charge Testing, Ingersoll-Rand Co., Phillipsburg, N. J.; *for mail,* 135 Ingraham Blvd., Hempstead, L. I., N. Y.

PITMAN, Philadelphia Section

KOCH, Robt. A. ('30; '35), 47 Elm Ave.
LAWRENCE, Philip (J'27), Research Engr., Socony-Vacuum Oil Co., Inc., Paulsboro; *for mail,* 220 Lexington Ave., Pitman.

PLAINFIELD, Plainfield Section

ADOLPHSON, Harry B. ('30), Designing Engr., Wood Newspaper Mchy. Corp., 688 S. 2nd St., Plainfield; *for mail,* 640 Westfield Ave., Elizabeth.
AYER, Luther S. ('14), Mgr., Internatl. Motor Co., S. 2nd St.
BALCOM, John A. ('24; '35), 933 E. 7th St.
BIGELOW, Chas. H. ('04), Cons. Mech. & Elec. Engr., Indus. Plants, 981 Kenyon Ave.
CRESSY, Morton S., Jr. (J'32), Engr. of Div. "A," Calco Chem. Co., Inc., Bound Brook; *for mail,* 1133 Prospect Ave., Plainfield.

DAWLEY, Clarence A. ('04; '12), Cons. Engr., N. J. Meter Co.; *for mail*, 1234 Watchung Ave.
DE LEEUW, A. L. ('01), Cons. Engr., 1024 Park Ave.
GALLAHER, Alvan H. ('14; '20), Power Engr., 683 W. 7th St.
HASLACH, Jos. P. ('24), Parkside Rd.
HAYDOCK, John ('34), Managing Editor, American Machinist, McGraw-Hill Publ. Co., 330 W. 42nd St., New York, N. Y.; *home address*, 1516 Watchung Ave., Plainfield, N. J.
HELMER, N. Arthur ('18), Cons. M. E., Helmer Co., Engrs., P. O. Box 54.
HEROUX, Leo H. (J'36), Ch. Inspr., Walker-Turner Co., Plainfield; *for mail*, 34 Regent St., N. Plainfield.
HIBBARD, Henry D. ('83), Life Member; Cons. Metallurgist, 144 E. 7th St.
JOBIN, F. J. ('26; '34; '35), 834 Carlton Ave.
KELLY, Philip M. ('21; '25; '35), Research Engr., Cent. R. R. of N. J., Jersey City; *for mail*, 126 Netherwood Ave., Plainfield.
KOCH, H. G. (J'33), Research Engr.; Johns-Manville Research Lab., Manville; *home address*, 608 Madison Ave., Plainfield, N. J.
LANGSTROTH, Clifford B. ('12; '19), Engr. in Charge of Welding, Am. Locomotive Co., 30 Church St., New York, N. Y.; *for mail*, 1317 Putnam Ave., Plainfield, N. J.
MAIR, Kenneth T. ('30; '35), Engr. & Designer, Am. Terry Derrick Co., S. Kearny; *for mail*, 218 E. 6th St., Plainfield.
MERRILL, Eustace I. (J'29), 124 W. 8th St.
MORSE, Carl K. ('28), 1345 Watchung Ave.
PETERSON, Palmer A. ('30), Ch. Engr., Admin., Gen. Chem. Co., 40 Rector St., New York, N. Y.; *for mail*, 966 Sherman Ave., Plainfield, N. J.
RATHGEB, Albert ('26; '35), 734 Park Ave.
RYDER, Geo. C. (J'30), Cadet Engr., Pub. Serv. Elec. & Gas Co., Newark; *for mail*, 615 E. Front St., Plainfield.
SARGENT, Ralph N. ('30), Pres., Sargent Utilities, Inc.; *for mail*, 113 Myrtle Ave.
SCOTT, Walter C. ('18; '35), Mgr., Mem. Firm, Walter Scott & Co.; *for mail*, 418 E. Front St.
SMITH, Briton O. ('24), Asst. Engr., Charge Design, Gibbs & Cox, Inc., 21 West St., New York, N. Y.; *for mail*, 820—3rd Pl., Plainfield, N. J.
UCKO, Bernard (J'27), M. E., Internatl. Motor Co.; *for mail*, 324 Franklin Pl.
WHEATON, Wm. E. ('21; '35), Wks. Mgr., Walter Scott & Co., South Ave.; *for mail*, 818 Webster Pl.

POMPTON LAKES, Metropolitan Section

BENESH, Jos. A. (J'30), Time Study Engr., Am. Hard Rubber Co., Butler; *for mail*, 729 Colfax Ave., Pompton Lakes.
LAUCK, Alfred W. (J'33), 83 Perrin Ave.

PORT READING, Metropolitan Section

FILER, Jas. ('29), Ch. Engr., Power Plant & Car Dumper, Reading Co., Port Reading; *for mail*, 442 Rahway Ave., Woodbridge.

PRINCETON, Metropolitan Section

ANDERSON, Richard T. ('19; '20), Gen. Mgr., Paterson Parchment Paper Co., Bristol, Pa.; *for mail*, R. F. D. 3, The Great Road, Princeton, N. J.
CULVER, Edw. P. ('18; '25; '30), Assoc. Prof. M. E., Princeton Univ.; *for mail*, Graduate College.
GREENE, Arthur M., Jr. ('95; '03; F'36), Manager, '13-'16; Vice-President, '16-'18; Dean, Sch. of Engrg., Prof. M. E., Princeton Univ.; *for mail*, Farview, 139 Fitz Randolph Rd.
LUKS, Kraemer ('28; '32), Cons. Engr., 68½ Nassau St.
MILLER, Alten S. ('14), 80 Westcott Rd.
RAHM, Louis F. ('23; '34), Asst. Prof., Princeton Univ.; *for mail*, 188 Prospect Ave.
SORENSON, Alfred E. (J'27), Asst. Prof. M. E., Princeton Univ.; *for mail*, 1 Harris Rd.
WILLSON, Fred'k N. ('83), Prof. Emeritus of Graphics, Princeton Univ., P. O. Box 28.

RAHWAY, Plainfield Section

BARRON, Donald B. (J'35), Asst. Plant Engr., Am. Steel Fdy. Co., Ave. L & Edward St., Newark; *for mail*, 112 Hamilton St., Rahway.
DORWARD, Jas. Lee ('31), Engr., Mech. Dept., Rockefeller Center, Inc., 30 Rockefeller Plaza, New York, N. Y.; *for mail*, 770 Stone St., Rahway, N. J.
EBERLE, Fred H. ('20; '35), M. E., Stand. Oil Devel. Co., P. O. Box 37, Elizabeth; *for mail*, 940 Maurice Ave., Rahway.
HARDY, Rufe Jas. (J'31), Instr. Indus. Science, Rahway High Sch.; *for mail*, 1105 Charlotte Pl.
JANDRISEVITS, Peter (J'33), Student, Engrg. Dept., Merck & Co., Inc., Rahway; *for mail*, Avenel.
NUGEY, Anthony L. ('34; '35), 2 Pierpont St.
OPDYKE, Wm. J. (J'28), Mfg. Engr., Hyatt Roller Bearing Div., Gen. Motors Corp., 4th St., Harrison; *for mail*, 88 Esterbrook Ave., Rahway.
PEARCE, Robt. T. ('13), M. E., Wheatena Corp., Rahway; *for mail*, 239 Scotch Plains Ave., Westfield.

RAMSEY, Metropolitan Section

MIDDLETON, Fergus S. (J'28), The Birches.

RIDGEFIELD, Metropolitan Section

WEISS, Arthur J. ('22; '26; '35), Plant Engr., Lowe Paper Co., Church St., *for mail*, 949 Maple Ave.

RIDGEFIELD PARK, Metropolitan Section

SCHNEPP, Chas. F. ('36), 399 Main St.

RIDGEWOOD, Metropolitan Section

BRADLEY, Frank L. ('20; '27; '30), Plant Engr., Forstmann Woolen Co., 2 Barbour Ave., Passaic; *for mail*, 355 Meadowbrooke Ave., Ridgewood.
CHRISTIE, Wm. D. (J'29), Power Plant Designing Engr., Christie & Tichenor, 69 Dey St., New York, N. Y.; *for mail*, 107 Southern Pkwy., Ridgewood, N. J.
HUGHES, Robt. G. ('08), 125 Claremont Rd.
JOHNSON, Clarence N. ('21), Cons. Engr., 342 N. Van Dien Ave.
KUGLER, Arthur Noble (J'25), M. E., Applied Engrg. Dept., Air Reduction Sales Co., 60 E. 42nd St., New York, N. Y.; *for mail*, 118 Sherwood Rd., Ridgewood, N. J.
LYALL, Wm. L. ('87; '93), Chmn. Bd., Brighton Mills, 55 Brighton Rd., Allwood, Clifton; *for mail*, 82 Fairmount Rd., Ridgewood.
ROOT, Fred'k J. ('18; '35), 223 Kenilworth Rd.
SCHLEGEL, N. C. ('30; '35), 207 Emmet Pl.
SUMMERVILLE, F. Rudyard (J'28), Salesman, Cheel Construction Co., Inc., 254 Sheridan Ave., Ho-Ho-Kus; *for mail*, 288 Orchard Place, Ridgewood.

RIVER EDGE, Metropolitan Section

PADGETT, W. Clark (J'36), Cadet Engr., Pub. Serv. Elec. & Gas Co., Kearny Generating Sta., Kearny; *for mail*, 848 Bogart Rd., River Edge.

RIVERSIDE, Philadelphia Section

HOWE, Jas. A. ('27), Wks. Mgr., Keystone Watch Case Corp., Riverside; *for mail*, Mt. Holly Rd., R. F. D., 3, Medford.

RIVERTON, Philadelphia Section

GOOD, Paul E. ('15), Cons. Engr., Blower & Compressor Dept., Elliott Co., 718 Frick Bldg., Pittsburgh, Pa.; *for mail*, 407 Linden Ave., Riverton, N. J.
HOLLERITH, Richard (J'25), 307 Shrewsbury Rd.

ROCKAWAY, Metropolitan Section

FLORCYK, Edw. M. ('20; '25; '35), Ch. Engr., Charge Design, Stapling Mchs. Co.
IGLEHEART, Geo. P. ('18; '22; '35), V. P., Charge Engrg. & Prod., Stapling Mchs. Co.
WILLIAMS, Clayton H. (J'36), Design Dept., Stapling Mchs. Co., Rockaway; *for mail*, Church St., Wharton.
WOLSDORF, Henry A. ('19; '25; '35), Asst. Dir. Research, Package Research Lab.; *for mail*, 78 Ogden Ave.

ROSELLE, Plainfield Section

CHAMBERS, Chas. E. ('13), Pres., 1st Natl. Bank of Roselle; *for mail*, 260 E. 3rd Ave.
GITTENS, E. Donald (J'35), 447 E. 3rd Ave.
NEWCOMB, Franklin L. ('14; '21; '27), Supvg. Engr., Stand. Oil Devel. Co., P. O. Box 37, Elizabeth; *home address*, 232 E. 3rd Ave., Roselle.
SCOVILLE, Warren E., Jr. (J'34), 134 E. 7th Ave.

ROSELLE PARK, Metropolitan Section

BURTENSHAW, Chas. D. ('22; '28; '35), Engr., Charge Prod. & Design, Pulverizing Mchy. Co., 120 Valley Rd.
KAMPISH, Nick S. (J'34), 214 E. Lincoln Ave.
MESSERSMITH, Einar ('24; '35), 429 E. 3rd Ave.
RICE, Freeman J. ('29; '35), Tech. Interviewer, U. S. Dept. of Labor, Employment Serv., Fed. Bldg., Newark; *for mail*, 115 Grant Ave., E., Roselle Park.

RUTHERFORD, Metropolitan Section

AVIGNONE, Cesare J. (J'31), 505 Stuyvesant Ave.
BERLEY, Eugene F. (J'35), 277 Orient Way.
BERLEY, Max E. ('21), Devel. Engr., U. S. Steel Corp., Belleville; *for mail*, 277 Orient Way, Rutherford.
BROWN, Ronald Benj. ('23; '35), Engr., Association Bldg.; *for mail*, 141 E. Pierrepont Ave.
CASTRO, H. Edward (J'33), 227 Fairview Ave.
DUCOMMUN, Edw. ('98; '03), Partner, Stephen Van Zandt, Inc.; *for mail*, 190 Prospect Pl.
HEINEMAN, John (J'35), Asst. Sales Mgr., Vulcanized Rubber Co., 261—5th Ave., New York, N. Y.; *for mail*, 41 Carmita Ave., Rutherford, N. J.
JENKS, L. Howard ('91), Retired; 25 W. Park Pl.
McGIBBON, Donald G. (J'36), Clerk, Pur. Dept., Gen. Am. Transportation Corp.; *for mail*, 4032 Parrish Ave., E. Chicago, Ind.; *home address*, 27 Courrier Pl., Rutherford, N. J.
PROBST, Jos. J. R. (J'35), 19 Hasbrouck Pl.
WHITE, Edw. Francis ('91), Cons. Engr., Sulphur Smelting & Refining Plants, 50 Maple St.
WOOD, Chas. S. (J'35), Sales Engrg., Stephens-Adamson Mfg. Co., 50 Church St., New York, N. Y.; *for mail*, 35 Courrier Pl., Rutherford, N. J.

SALEM, Philadelphia Section

RANNO, Dwight B. ('23; '31), Asst. Supt., Deepwater Operating Co., P. O. 596, Penns Grove; *for mail*, R. D. 1, Salem.

SAYREVILLE, Metropolitan Section

CASEY, John Edw. ('24; '35), Raritan River Plant, Jersey Cent. Power & Light Co.
LIVINGSTON, Lafayette W. (J'33), Charge Opera. & Maint. of Power House, Titanium Pigment Co., Inc., Sayreville; *for mail*, Box 37, Fords.

SCOTCH PLAINS, Metropolitan Section

HOLLINGSWORTH, Samuel ('99; '07).
LAYAT, Felix ('12), Retired.

SEWAREN, Plainfield Section

MULLER, Raymond W. ('16; '19; '35), Wks. Engr., Vulcan Detinning Co.

SHORT HILLS, Metropolitan Section

GIBSON, Robt. M. ('22; '35), C. E., Design & Survey, Koppers Co., Kearny; *for mail*, Box 219, Short Hills.
HODGKINSON, Geo. A. (J'27), Fuel Engr., Pub. Serv. Elec. & Gas Co., 80 Park Pl., Newark; *for mail*, Northern Dr., Short Hills.

SOMERVILLE, Metropolitan Section

KILDEBO, Howard M. (J'35), Mch. Designer, Research Dept., Johns-Manville Corp., Manville; *for mail*, 16 S. Daughty Ave., Somerville.
REEVE, Kenneth A. (J'33), Constr. & Maint. Engr., Calco Chem. Co., Inc., Bound Brook; *for mail*, 145 Mountain Ave., Somerville.
REYNOLDS, Edw. A. (J'36), 314 E. Main St.
WEINLAND, Clarence E. (J'33), 21 W. High St.

SOUTH ORANGE, Metropolitan Section

CARLTON, Jos. R. ('18), Engr., Pub. Serv. Elec. & Gas Co., 938 Clinton Ave., Irvington; *home address*, 23 Holland Rd., S. Orange.
CULLIMORE, A. R. ('33), Pres., Newark College of Engrg., 367 High St., Newark; *for mail*, 158 Garfield Pl., S. Orange.
EBERHARDT, Frank E. ('07; '25), Pres., Gen. Mgr., Newark Gear Cutting Mch. Co., 69 Prospect St., Newark; *for mail*, 234 Raymond Ave., S. Orange.
FARR, Walter G. ('24; '35), Devel. Engr., Congoleum Nairn, Inc., 195 Belgrove Dr., Kearny; *for mail*, 69 Harding Dr., S. Orange.
MORGAN, Col. John Davis ('17; '35), Cons. Engr., 60 Wall St., New York, N. Y.; *for mail*, "Highhickory," Wyoming Ave., S. Orange, N. J.
SPENCER, Alfred Chas., Jr. (J'28), Research Engr., Stand. Oil Devel. Co., Elizabeth; *for mail*, 384 Turrell Ave., S. Orange.
STANWICK, Chas. A. ('20; '35), 131 Rynda Rd.

SUMMIT, Metropolitan Section

BACKER, Gerald H. (J'33), 32 Tulip St.
DARBY, John ('07), 166 Oakridge Ave.
EMMONS, Nelson A. ('24; '30; '35), Sales Engr., Self Winding Clock Co., 205 Willoughby Ave., Brooklyn, N. Y.; *for mail*, 44 Sunset Dr., Summit, N. J.
HODGSON, Alec W. ('10), Asst. Engr., N. Y. Edison Co., 4 Irving Pl., New York, N. Y.; *for mail*, 92 Mountain Ave., Summit, N. J.
LEMBECK, Otto A. ('13), 60 Hillcrest Ave.
McILHINEY, James G. (J'35), Serviceman, Internatl. Business Mchs. Corp., 95 Madison Ave., New York, N. Y.; *for mail*, 21 Oak Ridge Ave., Summit, N. J.

MOLE, Harvey E. ('01), P. O. Box 205.
STANLEY, Carroll M. ('21; '23), Sales Engr., Oliver United Filters, Inc., 33 W. 42nd St., New York, N. Y.; *for mail*, 33 Bedford Rd., Summit, N. J.

TEANECK, Metropolitan Section

MAURER, Wm. R. ('28; '35), 311 Demott Ave.
ROSSHEIM, David B. ('35), M. E., Charge Mech. Design & Metal., M. W. Kellogg Co., 225 Broadway, New York, N. Y.; *for mail*, 299 Van Buren Ave., Teaneck, N. J.

TENAFLY, Metropolitan Section

GIFFELS, John E. ('15; '20; '27), Res. Engr., Bogota Plant, Robt. Gair Co., 155 E. 44th St., New York, N. Y.; *for mail*, 204 W. Clinton Ave., Tenafly, N. J.

TOTOWA BOROUGH, Metropolitan Section

ZABRISKIE, Claude I. ('21; '35), Supt., Sipp-Eastwood Corp., Keen St. & Erie R. R.; *for mail*, 341 Totowa Rd.

TOWNLEY-UNION, Metropolitan Section

FORSYTHE, Chas. F. (J'29), Field Office Mgr., Baker Smith & Co., Inc., 576 Greenwich St., New York, N. Y.; *for mail*, 983 Townley Ave., Townley-Union, N. J.

TRENTON, Philadelphia Section

BACSO, Paul A. (J'30), Draftsman, Thermoid Rubber Co., White Head Rd.; *for mail*, 1032 Chambers St.
BENEDICT, Walter E. ('28; '34; '35), Plant Mgr., Sloane Blabon Corp., Trenton, N. J.; *for mail*, Black Rock Rd., Yardley, Pa.
BIRMANN, Rudolph ('23; '30), Designing Engr., De Laval Steam Turbine Co.
BRADLEY, Victor A. (J'29), M. E., Devel. & Mgmt. Problems, Panelyte Corp., Enterprise Ave.
BRYAN, Justus L. ('30; '35), Layout Draftsman & Checker, De Laval Steam Turbine Co.; *for mail*, 1202 Pennington Rd.
CRISSEY, Clarence P. ('12), Asst. Engr., De Laval Steam Turbine Co., Trenton; *for mail*, 14 Monroe Ave., Lawrenceville.
DIETZ, Franklin M. (J'25), Asst. Engr., Centrifugal Pump Design, De Laval Steam Turbine Co., Notingham Way.
ENGVALL, Harry ('28; '35), Gen. Turbine Design, De Laval Steam Turbine Co.; *for mail*, 534 Norway Ave.
FISHER, David F. (J'32), Tech. Apprentice, Am. Steel & Wire Co.; *for mail*, 101 Jackson St.
GARTMANN, Hans ('30; '35), De Laval Steam Turbine Co.
GLINZ, Fred (J'31), Engr., De Laval Steam Turbine Co.; *for mail*, 15 Ewing St.
HALDEMAN, Russell R. (J'33), Exper. Engr., De Laval Steam Turbine Co.; *for mail*, 833 Hamilton Ave.
HENNIG, Fritz O. (J'34), Designer, De Laval Steam Turbine Co.; *for mail*, 721 Mayflower Ave.
HILL, Wm. H. ('29; '35), Pres., Baldwin-Hill Co., 501 Klag Ave.; *for mail*, 800 W. State St.
HUGHES, Minor Ivins (J'33), 46 Colonial Ave.
JOHNSON, Erie G. ('21), Supv., Tech. Dept., Sch. of Indus. Arts, W. State & Willow Sts.
JOHNSTON, Robt. S. ('21), Dir. Research, John A. Roebling's Sons Co., Trenton, N. J.; *for mail*, 6 Alton Rd., Yardley, Pa.
JURGENSEN, Chas. A. (J'34), Supt., Pump Shop, De Laval Steam Turbine Co.; *for mail*, 114 Fetter Ave.
LEE, Bunyan W. ('25), Engr., Inspections, Royal Indemnity Co., 150 William St., New York, N. Y.; *for mail*, 1897 Pennington Rd., Trenton, N. J.
LOIDL, Jos. M. (J'34), 435 William St.
LUPKE, Paul, Jr. ('22; '35), Cons. Engr., Essex Rubber Co., P. O. Box 501; *for mail*, 771 E. State St.
MASON, Sidney P. (J'30), Mch. Designer, De Laval Steam Turbine Co.; *for mail*, 19 Andrew St.
MITCHELL, Chas. J. B. (J'34), 794 Klockner Ave.
MULLOWNEY, P. E. (J'35), Engr., Charge Instr., Luscombe Aircraft Devel. Corp., Mercer Airport, P. O. Box 73, W. Trenton; *home address*, 602 W. State St., Trenton.
PETERSON, Arvid ('21), Ch. Engr., Centrifugal Pump & Compressor Dept., De Laval Steam Turbine Co.; *for mail*, 1216 Riverside Ave.
REEVES, Clifton ('21), Clifton Reeves & Assoc., Rm. 1101, Broad St. Bank Bldg.
SLAVENAK, Adam J., Jr. (J'29), Draftsman, De Laval Steam Turbine Co.; *for mail*, 21 Samdin Blvd.
SUTHERLAND, D. Manson, Jr. (A'26), Cons. Chem. Engr., 143 E. State St.
TRETHAWAY, Wm., Jr. ('24; '26; '35), Gen. Mgr., Murray Rubber Co.; *for mail*, 1064 Stuyvesant Ave.
WALLER, C. Richard ('13), Ch. Engr., De Laval Steam Turbine Co.; *for mail*, 922 Bellevue Ave.
WATSON, Herbert L. ('07; '21), Gen. Sales Mgr., De Laval Steam Turbine Co.; *for mail*, 27 Whittier Ave.

UNION, Plainfield Section

HARTKOPF, H. A. (J'36), Supvr., Charge Parts Prods., Weston Elec. Instrument Corp., Newark; *home address*, 718 Midland Blvd., Union.

UNION CITY, Metropolitan Section

BURKE, Robt. E. ('19), Treas., Censullo Burke Constr. Co., 613—15th St.
PINSAN, Philip E. (J'35), 342 Palisade Ave.
SELTZER, Henri S. (J'27), Prod. Engr., Dr. Bengué, 417 Kerrigan Ave.
STRAZZABOSCO, G. J. A. (J'34), 806—22nd St.
TROST, Henry J. ('32), Receiving Dept., Sears, Roebuck & Co., Blvd. & 32d St.; *for mail*, 512—29th St.
ZIMMERMAN, Geo. F. (J'35), 912 Hudson Ave.

UPPER MONTCLAIR, Metropolitan Section

BORCHARDT, Albert H. ('12; '16; '35), Asst. V. P., Charge Application Engrg. Sales, Worthington Pump & Mchy. Corp., Worthington Ave., Harrison; *for mail*, 90 Cooper Ave., Upper Montclair.
BROWN, Roger Stuart ('22; '35), V. P., Sales, Calorizing Co., 136 Liberty St., New York, N. Y.; *for mail*, 6 Princeton Pl., Upper Montclair, N. J.
CAWLEY, Geo. ('21; '35), 382 Highland Ave.
COUCH, A. D. ('15; '22; '35), 139 Haddon Pl.
CROLL, A. G. (A'01), 520 Park St.
FERNALD, Henry Barker, Jr. (J'32), Metal. Lab. Asst., Wright Aero. Corp., 1120 E. 19th St., Paterson; *for mail*, 145 Lorraine Ave., Upper Montclair.
HOBEIN, Kingsland (J'36), Test Observer, Exper. Test Dept., Wright Aero. Corp., Paterson; *for mail*, 130 Edgemont Rd., Upper Montclair.
KENT, Henry R. ('01), 160 Gordonhurst Ave.
MEAD, Chas. A. ('13), Life Member; Engr., Charge Div. of Bridges & Grade Crossing Elimination, Bd. Pub. Utility Commrs., N. J., 1060 Broad St., Newark; *for mail*, 165 Wildwood Ave., Upper Montclair.
MORRISON, Montford ('19), 176 Wildwood Ave.
OPPENHEIMER, P. H. ('27; '33), Design Engr., Alco Products, Inc., 30 Church St., New York, N. Y.; *for mail*, 108 Buckingham Rd., Upper Montclair, N. J.
PLASS, Robt. H. ('24), Cons. Engr., 33 Marion Rd.
PRINCE, Duffield ('16), Doherty Research Co., 60 Wall St., New York, N. Y.; *for mail*, 133 Summit Ave., Upper Montclair, N. J.
SAXBY, Lewis E. ('17; '21), Engr., Charge Oil Htg. Div., Behrens Bros., Secaucus; *for mail*, 563 Park St., Upper Montclair.
TILLSON, Benj. F. ('15; '16), Cons. Engr., 470 Grove St.

VENTNOR, Philadelphia Section

DYER, Frank L. (A'01), Pat. Expert, 24 N. Cornwall Ave.
EHRHART, R. N. ('14), 5801 Ventnor Ave.

VERONA, Metropolitan Section

KENT, Robt. T. ('05; '19), 1 Wayland Dr.

VINELAND, Philadelphia Section

MARUFFI, Jos. P. (J'34), 417 Landis Ave.

WASHINGTON, Anthracite-Lehigh Valley Section

JOYCE, Reginald (J'30), Asst. Tech. Dir., Consumers Research Inc.; *for mail*, R. D. 2.
SCHLINK, F. J. ('17; '19; '24), Pres. & Tech. Dir., Consumers Research, Inc.

WEEHAWKEN, Metropolitan Section

CADY, Harrison R. (J'16), M. E., Hackensack Water Co., Weehawken; *for mail*, 367 Maitland Ave., W. Englewood.
HENSELER, Wm. J. (J'36), Office & Field Wk., W. G. Fritz Co., Inc., 69 Main St., W. Orange; *for mail*, 35—6th St., Weehawken.
KOENIG, Eugene H. (J'32), Engr., Keuffel & Esser Co., Adams St., Hoboken; *for mail*, 45—2nd St., Weehawken.
WURGEL, René A. ('20; '22; '27), Asst. Engr., Investigation Unit Expt., Fed. Communications Comm., Washington, D. C.; *for mail*, 134 Oak St., Weehawken, N. J.

WEST CALDWELL, Metropolitan Section

HEQUEMBOURG, Jerome E. (J'28), M. E., Sales Dept., Gould & Eberhardt, 433 Fabyan Pl., Irvington; *home address*, 6 Spring Lane, W. Caldwell.

WEST ENGLEWOOD, Metropolitan Section

NOSS, Oscar F. ('19), 1300 Longfellow Ave.
VOLCKHAUSEN, Walter J. (J'28) Engr., Draftsman, Am. Mch. & Fdy. Co., 55th St. & 2nd Ave., Brooklyn, N. Y.; *for mail*, 1325 Dickerson Rd., W. Englewood, N. J.

WESTFIELD, Plainfield Section

BARKER, Virgil D. ('24; '33), Engr., Charge Planning & Mech. Devel., West. Elec. Co., Inc., 395 Hudson St., New York, N. Y.; *home address*, 639 Shadowlawn Dr., Westfield, N. J.
BOWEN, Wm. Spencer ('18; '35), Pres., Bowen Research Corp., Box 18, Garwood; *for mail*, 720 Highland Ave., Westfield.
COOLEY, Erwin S. ('10), Mfrs. Rep., 15 Evergreen Rd.
HEBLER, Wm. O. ('33; '35), Cons. Engr., 830 Broad St., Newark; *home address*, 651 Coleman Pl., Westfield.
INGLIS, R. N. ('17), 617 Lawrence Ave.
QUICK, Howard Prescott ('94), 124 Eaglecroft Rd.
REYNOLDS, Spencer W. (J'33), 531 St. Mark's Ave.
RUDDY, Wm. ('11; '21), 215 Harrison Ave.
SEIBERT, Stewart H. (J'24), 715 Highland Ave.
SPENCER, Frank C. ('08; '12), Planning Engr., Charge Tool & Gage Design, West. Elec. Co., Inc., 100 Central Ave., Kearny; *home address*, 620 Shadowlawn Dr., Westfield.
SPENCER, Frank C., Jr. (J'34), Asst. Engr., Mfg. & Planning, West. Elec. Co., Inc., Central Ave., Kearny; *for mail*, 620 Shadowlawn Dr., Westfield.
WIBOM, Eric G. ('20; '28; '35), Wychwood Rd. & Cherry Lane.
WICK, G. Rodney (J'32), Opera. Engr., Alco Products, Inc., 30 Church St., New York, N. Y.; *for mail*, 230 Sylvania Pl., Westfield, N. J.
WILSON, Christian, Jr. ('19; '28), Sales Engr., Yarnall Waring Co., Chestnut Hill, Philadelphia, Pa.; *for mail*, 116 St. Paul St., Westfield, N. J.

WEST NEW YORK, Metropolitan Section

BATTIN, Wm. I., Jr. (J'32), Commercial Cadet, Publ. Serv. Elec. & Gas Co., 701 Bergenline Ave., W. New York, N. J.; *for mail*, 360 W. 28th St., New York, N. Y.
COVINO, Adolph O. ('31; '35), Pres., Jersey Engrg. Co., 726 Park Ave.
FRIGIOLA, Nicholas F. (J'25), Engr., Safety, Travelers Ins. Co., 55 John St., New York, N. Y.; *for mail*, 101—20th St., W. New York, N. J.
SMOLDEREN, Ferdinand V. (J'24), Purchasing, Div. of Procurement, Treas. Dept., 1060 Broad St., Newark; *for mail*, 784 Hudson Ave., W. New York.
ZIEVE, Wm. A. (J'33), Engr., Charge Design, Rubinger Sportswear Corp., 567—9th St., W. New York, N. J.; *for mail*, 45 Bay 23rd St., Brooklyn, N. Y.

WEST ORANGE, Metropolitan Section

BERGGREN, Karl G. ('27; '35), Engr., Thos. A. Edison, Inc.; *for mail*, 62 Valley Way.
BUCHANAN, Jaffrey P. ('21) 234 Gregory Ave.
CROWLEY, Henry L. ('18; '25; '27), Pres., Henry L. Crowley & Co., Inc., 1 Central Av.
KAYE, Jas. W. ('27; '35), Ch. Engr., Thos. A. Edison, Inc.; *for mail*, 33 Franklin Av.
KINGSLEY, Wm. H. (J'24), 5 Belgrade Terrace.
McNEAR, Wm. Fairlie (J'26), 20 Gilbert Pl.
MORRIS, Benj. F. ('30; '35), Mgr., Engrg. & Mfg., Storage Battery Div., Thos. A. Edison, Inc., W. Orange; *for mail*, 71 Park Ave., Caldwell.
NICHOLSON, Richard, Jr. (J'35), 136 Forest Hill Rd.
SMITH, Albert K. ('17; '23; '27), Pres., Gen. Mgr., Caravan Co., Inc., 1 Meeker St.; *for mail*, 3 Oxford Terrace.
TRESOUTHICK, S. G. ('21; '25; '35), Survey Engr., Stand. Oil Co. of N. J., 29 Spring St., W. Orange; *for mail*, 531 Sherman Ave., Roselle Park.

WESTVILLE, Philadelphia Section

SMITH, Henry Bassett (J'36), 419 Broadway.

WESTWOOD, Metropolitan Section

SMEND, Wm. C. ('21), 21 Cypress St.

WHARTON, Metropolitan Section

WILLETT, Francis M. ('16; '22; '35), Assoc. M. E., Picatinny Arsenal, Dover; *for mail*, 1 Ford Ave., Wharton.

WHIPPANY, Metropolitan Section

FISHER, Elbert C. ('13), Engr., Agar Mfg. Corp., Thomas St.

WOODBURY, Philadelphia Section

GUNN, Thos. M. ('11), M. E. Research Lab., Socony-Vacuum Oil Co., Inc., Paulsboro; *for mail*, 223 Holroyd Pl., Woodbury.

WOODBURY HEIGHTS, Philadelphia Section

MOORE, Wm. H. (J'36), Airline Technician Student, Boeing Sch. of Aero., Oakland Airport, Oakland, Calif.; *home address*, Lake Ave., Woodbury Heights, N. J.

WOODCLIFF, Metropolitan Section

EKEGREN, Oscar J. (J'33), 304—32nd St.
MEHLIG, Theo. P. (J'34), 312—28th St.
STRAHL, O. Robt. (J'32), 237—30th St.
ZIEGLER, Wilfred L. (J'36), 1021 Broadway.

WOOD-RIDGE, Metropolitan Section

LEE, Edw. R., Jr. (J'34), Engrg. Design Div., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail*, 500 Marlboro Rd., Wood-Ridge, N. J.

WYCKOFF, Metropolitan Section

LESLIE, John S. (J'35), Prod. Dept., Leslie Co., Lyndhurst; *for mail*, Box 181, Wyckoff.

WYOMING, Metropolitan Section

KISSAM, W. M. (J'35), 109 Glen Ave., Maplewood.

NEW MEXICO

ALBUQUERQUE

'ARRIS, Marshall E. ('35), Dean, College of Engrg., Prof. M. E., Univ. of New Mex.
'ERTIG, John L. ('27; '35), Tank Shop Foreman, Atchison, Topeka & Santa Fe Ry. Co.; *for mail*, 614 S. Carlisle Ave.
IOORE, Mortimer J. P. ('20; '35), P. O. Box 946.

'ARLSBAD

NDERSON, L. Douglass ('06; '13), Cons. Engr., Potash Co. of Am., Box 31.

ONCHAS DAM

'ISKUR, Stephen (J'32).

AS CRUCES

'HAMBERS, Wm. H., Jr. (J'34), Civilian Conservation Corps, Camp DSP 6 A, Company 1837, Tucson Ariz.; *for mail*, 435 N. Melendres St., Las Cruces, New Mex.

'A MADERA

'IENMIER, Harold (J'35), Commanding Officer, Company 1818, Civilian Conservation Corps, Albuquerque Dist.; *for mail*, Camp F-43-N.

ONUMENT

'IITH, Jas. K. (J'35), Student Engr., Natural Gasoline Corp., Box 1589, Tulsa, Okla.; *for mail*, Box 67, Monument, New Mex.

NEW YORK

.BANY, Schenectady Section

RROW, Chas. J. ('27), Cons. Engr., 50 State St.
AKE, Francis E. (J'01), Asst. Engr., Div. Engrg., N. Y. State Dept. Pub. Wks., Pub. Wks. Bldg., Albany; *for mail*, Box 61, Delmar.
'ND, Horace A. ('29; '30), Albany Office Mgr., Warren Webster Co.; *for mail*, 12 Ramsey Pl.
'TTRON, W. C. ('36), Supt. Power Plant, N. Y. Cent. R. R., W. Albany; *for mail*, 23 Glenwood St., Albany.
'HER, Jas. F. (J'33), Spec. Apprentice, Rolling Stock Dept., N. Y. Cent. R. R. Co., 466 Lexington Ave., New York; *for mail*, 5 Lincoln Ave., Albany.
CH, Harold W. (J'20), Publs. Supvr. Del. & Hudson R. R. Corp.
'RBES, Wm. G. ('24; '25; '35), Sales Engr., Shell Oil Co.; *for mail*, 325 Hamilton St.
'ASSEY, Philip P. ('26; '33; '35), 100 State St.
)DRICH, Thos. M. ('25; '35), Assoc. Valuation Engr., Pub. Serv. Comm., State Office Bldg.
)BERG, Harold F. (J'21), Asst. Supt. (Prod.), Albany Felt Co., 1333 Broadway.
'NRY, Francis D. (J'33), Test Wk., W. Albany Shops, N. Y. Cent. R. R.; *for mail*, 144 Kent St.

McGREW, J. A. ('16), Cons. Engr., Del. & Hudson R. R. Corp.
MERSEREAU, Theo. T. ('05), 4 Chestnut St.
MYERS, Arthur H. ('27; '35), Asst. Administrator, Wks. Progress Admin. of N. Y. State, Old Post Office Bldg.
PITKIN, Emerson S. B. (J'32), Maint. Man, Elec. Substa., New York Power & Light Corp.; *for mail*, 364 Quail St.
REISSIG, A. Richard (J'33), 26 Lexington Ave.
WHEELER, Seth, Jr. ('18), Cons. Engr., Rm. 713, 90 State St.

AMITYVILLE, L. I., Metropolitan Section

WILSON, Wm. R. (J'99), 61 Bennett Pl.

AMSTERDAM, Schenectady Section

FRADENBURGH, John (J'31), Mch. Designer, Exper. Dept., Mohawk Carpet Mills, Inc., Lyon St.; *for mail*, 378 Locust Ave.
KELLOGG, W. D. ('32), Ch. Engr., Charge Research, Mohawk Carpet Mills, Inc., 57 Lyon St.; *for mail*, 204 Market St.
MACLEOD, Alan S. (J'29), Ch. Draftsman, Maint. Engrg. Dept., Mohawk Carpet Mills, Inc., Lyon St.; *for mail*, 23 Storrie St.
MEARS, Sherman R. (J'36), Turbine Oper., N. Y. Power & Light Corp.; *for mail*, 33 Romeyn Ave.

AQUEDUCT, L. I., Metropolitan Section

CUOMO, Frank (J'33), 114-28 Old South Rd.

ARDSLEY-ON-HUDSON, Metropolitan Section

EDDISON, W. Barton ('13; '21; '35), Cons. M. E.

ARLINGTON, S. I., Metropolitan Section

AMOROSI, Guido ('28; '33; '35), Mgr. Stands. Dept., United Dry Docks, Inc., Arlington; *for mail*, 3339 Barker Ave., New York.

ASTORIA, L. I., Metropolitan Section

HEINZELMAN, Harold F. (J'27), Astoria Light, Heat & Power Co., Astoria; *for mail*, 761 E. 231st St., New York.
HURYCH, Jerome W. (J'23), M. E., E. E. & Ch. Engr., Rita Mfg. Co.; *for mail*, 2431 Kindred St.
MEAGHER, Francis J. ('27), Professional Engr., 31-34—30th St.
WOODS, Geo. E., Jr. (J'29), Astoria Light, Heat & Power Co.

AUBURN, Syracuse Section

AVERY, Howard W. (J'33), 99½ N. Fulton St.
CASEY, Paul N. ('23; '24; '35), Auburn Iron Co., 143 Kelsey St.; *for mail*, 2—2nd Ave.
COOKE, Harte ('97), M. E., McIntosh & Seymour Corp., 100 Orchard St.; *for mail*, 10 Jefferson St.
FOORD, Lieut. Comdr. Jas. L. ('15), R. D. 5.
GLANVILLE, Robt. H. (J'35), M. E., Charge Rates & Methods, Internatl. Harvester Co.
HOOKER, Ralph J. (J'28), McIntosh & Seymour Corp.
LEWIS, Jas. T. ('19), McIntosh & Seymour Corp.
LINFORD, John W. ('25), Asst. Sales Mgr., Diesel Eng. Div., Am. Loco. Co., Orchard St.; *for mail*, 229 N. Hoopes Ave.
NICHOLS, Wm. M. ('25; '30), Supt. of Constr., McIntosh & Seymour Corp.; *for mail*, 122 Walnut St.
PAUL, Ralph C. ('25; '35), Asst. to Mgr., Diesel Eng. Div., Am. Loco. Co.; *for mail*, 105 Mary St.
SCHULZ, G. E. ('17; '20), Pres. & Gen. Mgr., Nye & Wait Corp.; *for mail*, 96 South St.
SCHWEIZER, Paul Ernest ('30; '35), Charge Calculation Dept., Diesel Eng. Div., Am. Loco. Co., Auburn; *for mail*, Port Byron.
SEYMOUR, Jas. A. ('92), Retired; 64 South St.
SHORT, Herbert M. ('29; '32; '35), McIntosh & Seymour Corp.
SONTAG, Herbert P. ('25; '29; '35), M. E., Charge Maint. & Devel., Firth Carpet Co., 62 Columbus St.

BABYLON, L. I., Metropolitan Section

COCHRANE, Lewis ('18), P. O. Box 62.
DEALE, Robt. C. ('30), DeForest Ave.
GOTTSCH, Donald Chris (J'36), W. Islip Rd.
JOHNSON, Henry S. ('14), Supt. Highways, Town of Babylon; *for mail*, R. F. D. 14, G. E. Neck Rd.
LAHY, D. Orville (J'33), Safety Engr. & Payroll Auditor, Great Am. Indemnity Co., 175 W. Jackson Blvd., Chicago, Ill.; *for mail*, 78 S. Carll Ave., Babylon, L. I., N. Y.
PRICE, Gerald L. ('30; '35), Engr., Charge Constr., N. Y. State Dept. of Pub. Wks., Div. of Highways, 122 W. Main St., Babylon; *for mail*, 53 Weiden St., Farmingdale, L. I.

BAINBRIDGE

PROSS, Wm. C. (J'31), Plant Engr., Am. Plastics Corp.

BALDWIN, L. I., Metropolitan Section

MURRAY, Geo. J., Jr. (J'36), Cadet, U. S. Military Acad., West Point; *for mail*, 10 Grimm Pl., Baldwin.

BALDWINSVILLE, Syracuse Section

FORSSELL, Alfred G. (J'22), Engr., Sales, Morris Mch. Wks.; *for mail*, 18 Sunset Terrace.
LAGER, Carl A. ('93; '25), V. P., Charge Design, Morris Mch. Wks.; *for mail*, 17 Grove St.
McAULIFFE, Pierce J. ('19), V. P. & Gen. Mgr., Morris Mch. Wks.

BATAVIA

FIERO, Carl Donald (J'34), 213 Washington Ave.

BAY SHORE, L. I., Metropolitan Section

CURLEY, Matthew H. ('24; '35), Asst. Elec. Oper., Mgr., Suffolk Div., L. I. Lighting Co., 88 Main St.
KENWARD, Stanley B. (J'33), 45—5th Ave.
PATTHEY, Alfred R. (J'33), Inspr., Grumman Aircraft Engrg. Corp., Farmingdale, L. I.; *for mail*, 41 N. Clinton Ave., Bay Shore.
WATSON, Ward T. (J'30), Central Office Insideman, N. Y. Tel. Co., 4th Ave., Bayshore; *for mail*, 103 Main St., Sayville, L. I.

BAYSIDE, L. I., Metropolitan Section

CAVE, John R., Jr. (J'36), Indus. Engr., Charge Matl. & Time Studies Lily-Tulip Cup Corp., 15th St., College Point, L. I.; *for mail*, 217-07 Corbett Rd., Bayside.
HUNDLEY, Frank G. (J'31), Engrg. Dept., Neptune Meter Co., 192 Jackson Ave., Long Island City; *for mail*, 217-05—49th Ave., Bayside.
KITELEY, Wm. J. (J'30), 210-23—33rd Rd.
QUINN, Wm. H. ('30; '35), Dist. Mgr., Chain Belt Co., New York; *for mail*, 40-20—217th St., Bayside.
ROBBS, Wm. H. ('25; '30), Indus. Engr., 210-12 Crocheron Ave.

BAYVILLE, L. I., Metropolitan Section

SCHEIDT, Harry J. (J'36), Test. Bur., Steam Tester, Williamsburg Power Plant Corp., Brooklyn; *for mail*, Quincy Ave., Bayville.

BEACON, Metropolitan Section

BARDES, John H., Jr. (J'34), Estimator, Green Fuel Economizer Co., Inc., 627 Main St.; *for mail*, 5 Lincoln St.
BERGER, Jos. W. ('13), 579 Wolcott Ave.
ENDSLEY, Louis Eugene, Jr. (J'34), Engr., Engrg. Research Dept., Tex. Co., Beacon; *for mail*, Box 616, Main & Jackson Sts., Fishkill.
FINN, Wm. J. (J'27), Tex. Co.
KNIGHT, Albion W. ('21; '35), M. E. on Design & Tests, Green Fuel Economizer Co., Inc., 627 Main St.; *for mail*, 1 Wodell St.
WEAVER, Leon H. A. ('21; '25), Sales & Adv. Engr., Green Fuel Economizer Co., Inc., 627 Main St., Beacon; *for mail*, 38 Paulding Ave., Cold Spring.

BELLEROSE, L. I., Metropolitan Section

OATLEY, Henry C. (J'30), Engr. Asst., Testing & Opera., N. Y. Edison Co., 666—1st Ave., New York; *for mail*, 241-19—87th Ave., Bellerose.

BELLMORE, L. I., Metropolitan Section

WOLFE, Henry L. (J'31), 413 Mill Rd.

BINGHAMTON, Ithaca Section

CHARNO, Joseph (J'34), 143 Crestmont Rd.
FYNBOE, Christian (J'32), Plant Maint. & Constr. Engr., Agfa Ansco Corp., Charles St.
HOLFORD, Harry E. ('22; '35), Pres., Binghamton Fdy. & Mch. Co., Inc.; *for mail*, 8 Cedar St.
LE BARON, Francis E. (J'34), 31 Valley St.
MARUM, Otto ('31; '35), M. E., Asst. Ch. Engr., Agfa Ansco Corp.; *for mail*, 12 Grand Blvd.
PANITZ, Karl A. (J'32), Plant Engr., Charge Engrg. & Maint. Wk. for Process Depts., Agfa Ansco Corp., 29 Charles St.; *for mail*, 13 Mather St.
PETERMAN, Geo. W. ('22; '29; '35), Engr. Plant Layout, Agfa Ansco Corp.
STELZ, Frank F. ('27; '35), Mech. & Plant Engr., Agfa Ansco Co., Binghamton, N. Y.; *for mail*, 250 Central Ave., Jersey City, N. J.
WHEELER, Francis E. (J'32), Salesman & Engr., Shell East. Petroleum Products, Inc., 51-57 Clinton St., Binghamton; *for mail*, Box 2, Chenango Bridge.
WILDER, Cecil Lyman (J'33), Jr. Plant Engr., Agfa Ansco Corp.

BREWSTER, Metropolitan Section

HAWKINS, Eugene T. (J'34), 8 Garden St.

BRIARCLIFF MANOR, Metropolitan Section

STUNZI, J. Jacques ('20), Indus. Engrg., Elm Rd.

BRIGHTWATERS, L. I., Metropolitan Section

KRUMMEL, Louis C. ('01).

BROADALBIN, Metropolitan Section

ARTHUR, Theo. S. (J'28), Broadalbin Knitting Co.; *for mail,* Broadalbin.

BRONXVILLE, Metropolitan Section

HINTON, Edgar D. (J'33), 74 Gard Ave.
HOOVER, A. Pearson ('18), 10 Chatfield Rd.
TORCHIO, Philip, Jr. (J'31), Lawrence Pk.
WALSH, Thos. A. ('29), Safety Engr., Am. Optical Co., 70 W. 40th St., New York; *for mail,* 23 Bolton Gardens, Bronxville.

BROOKLYN, Metropolitan Section

ABRAHAMSON, Warren A. (J'31), Commercial Engr., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail,* 7420 Ridge Blvd.
ALBERTS, Matthew A. (J'23), Engr., Charge Design, Presto Lock Corp., 70 Washington St.; *for mail,* 1006—41st St.
ALGERI, Dante J. (J'34), Draftsman, Wks. Progress Admin.; *for mail,* 1734—65th St.
ALLEN, Richard M. (J'36), 110 Neptune Ave.
ALMAN, Lawrence C. (J'34), Engr. Designer, Saml. Cupples Envelope Co., 360 Furman St.; *for mail,* 3614 Ave. K.
AMORE, Jos. (J'36), Draftsman, Enterprise Engrg. Co., 782 Union St.; *for mail,* 1202—8th Ave.
AMREIN, Jos. ('29; '35), 622 Ave. C.
ANDERSON, Andrew F. ('15; '35), Teacher, Shopwork, City of New York; *for mail,* 234—79th St.
ANDERSON, C. Einar ('19), 268—75th St.
ANDERSON, David L. ('28), Engr., Charge Design, Intertype Corp., 360 Furman St.; *for mail,* 150 Senator St.
ANUSKIEWICZ, Michael W., Jr. (J'29), Supt.'s Asst., Greenpoint Plant, Brooklyn Union Gas Co., Maspeth & Varick Aves.
APPEL, Albert W. (J'36), Prod. Engr., Ford Instrument Co., Rawson St. & Nelson Ave., Long Island City; *for mail,* 99 Java St., Brooklyn.
ARENWALD, Mark E. ('30), 875 Ocean Pkwy.
ARICO, Leo Jos. (J'35), 2095 E. 7th St.
ARNOLD, Chas. B. ('26; '36), Div. Engrg., Brooklyn Edison Co., Inc., 380 Pearl St., Brooklyn; *for mail,* 15 Witley Court, Hempstead, L. I.
ASHKINAZY, Samuel B. (J'34), M. E., Charge Specifications, Gen. Instrument Corp., 829 Newark Ave., Elizabeth, N. J.; *for mail,* 786 Greene Ave., Brooklyn, N. Y.
BARNETT, Sydney A., ('17; '24; '35), Pres., Ray Proof Corp., 6905 Ridge Blvd.
BARTA, Geo. L., Jr. (J'33), 208 Macon St.
BASSOFF, A. Blair ('36), Ch. Engr., Sier Bath Co., 640 W. 58th St., New York; *for mail,* 8814 Bay Pkwy., Brooklyn.
BAUMAN, J. Arthur (J'36), 110 Montague St.
BAUSER, Lester E. (J'33), Fireman on Oil Still, Stand. Oil Co. of N. Y., 400 Kingsland Ave., Brooklyn; *for mail,* 104-25—111th St., Richmond Hill, L. I.
BECK, Gebhard C. ('26; '32; '35), Research Asst., Brooklyn Union Gas Co., 176 Remsen St.
BECKER, Wm. O. (J'29), M. E., Mergenthaler Linotype Co., 43 Hall St., Brooklyn; *for mail,* 8857—77th St., Woodhaven, L. I.
BEERS, Jos. L. (J'28), Engr., Charge Mch. Design, Julius Kayser & Co., 453 DeKalb Ave., Brooklyn, N. Y.; *for mail,* 452 Beardsley Ave., Bloomfield, N. J.
BEHRINGER, Chas. D. (J'33), Asst. Engr., Gen. Design, Maint., Steel & Tubes, Inc., 72-88 Scott Ave., Brooklyn; *for mail,* 132—70 Sanford Ave., Flushing, L. I.
BEHRMAN, Henry ('19; '24; '35), Merchandise Mgr., Brooklyn Union Gas Co., 176 Remsen St., Brooklyn; *for mail,* 30 Eastchester Rd., New Rochelle.
BELIAEFF, Stephen B. ('24; '35), Pres., Modern Mch. Corp., 285-7 N. 6th St.
BENEDICT, Otis, Jr. ('25; '35), Instr., Sch. of Sci. & Tech., Pratt Inst.
BENFER, Maurice F. (J'27), Indus. Engr., Julius Kayser & Co., 453 DeKalb Ave.; *for mail,* 55 Hanson Pl.
BERTELSEN, Christian ('29; '35), Engr., Charge Mch. Shop & Repairs, Dept. Water Supply, Gas & Elec., City of N. Y., Atlantic Ave. & Logan St.; *for mail,* 262—78th St.
BIALOG, Edw. S. (J'35), 575 Barbey St.
BILLIG, Philip J. (J'31), Secy., Treas., Paramount Welded Aluminum Products Corp., 195 Morgan Ave., Brooklyn; *for mail,* 1725 Andrews Ave., New York.
BIRKENLUND, Andrew E. (J'32), 165—70th St.
BIRKUKOFF, Roman R. (J'33), Engr., Charge Design, C. Spiro Mfg. Co., Dobbs Ferry; *for mail,* 565—85th St., Brooklyn.
BISCHOF, Gustave J. ('24; '31; '35), Cons. Engr., Cooling Tower Co., Inc., 15 John St., New York; *for mail,* 221 E. 3rd St., Brooklyn.
BITTNER, Claude E. ('26), Wks. Mgr., Intertype Corp., 360 Furman St., Brooklyn; *for mail,* 8738—84th St., Glendale, L. I.
BJONG, Leo (J'35), Engr., Devel. & Research, Pioneer Instrument Co., 754 Lexington Ave.; *for mail,* 826—43rd St.
BLAIR, Tom H. ('32), Factory Mgr., E. W. Bliss Co., 53rd St. & 2nd Ave.
BOCK, Louis S. (J'31), Sales Engr., Brooklyn Union Gas Co., 176 Remsen St., Brooklyn; *for mail,* 143 E. 39th St., New York.
BOENIG, Robt. W. ('92; '02), Fuel Engr., Acme Min. & Fuel Corp., 46 Sutton St.; *for mail,* 157 Meeker Ave.
BOGGIANO, Jas. E. ('24; '32), 294 Cumberland St.
BOLLINGER, Geo. W. (J'30), Jr. Engr., Brooklyn Edison Co., Inc., 1 Hudson Ave., Brooklyn; *for mail,* 221-06 Murdock Ave., Queens Village, L. I.
BOLTIZAR, Albert L. ('26; '33; '35), M. E., Supt., Holder Sta., Kings County Ltg. Co., 6740—4th Ave.; *for mail,* 43 Marine Ave.
BONDY, Winfield S. (J'35), 1120 Brighton Beach Ave.
BOURGARDE, Lester F. (J'25), Ch. Engr., Brooklyn Branch, York Ice Mchy. Corp., 42nd St. & 2nd Ave., Brooklyn; *for mail,* 12 Hazel Pl., Floral Park, L. I.
BREVETTA, Frank C. (J'33), V. P., Charge Sales, Amthor Testing Instrument Co., Inc., 10 Leo Place; *for mail,* 1324—77th St.
BROWN, Percy ('16; '35), Secy., Sales Mgr., Brass Goods Mfg. Co., 346 Eldert St.
BROWNSCOMBE, Philip J. (J'36), Design Engr., Arma Engrg. Co., 254—36th St., Brooklyn, N. Y.; *for mail,* 364 Elmwood Ave., E. Orange, N. J.
BRUHN, Neils (J'24), Steam Tester, Williamsburgh Power Plant Corp., 500 Kent Ave., Brooklyn; *for mail,* 326 Oak Ave., Cedarhurst, L. I.
BRUNSCHWIG, Marvin (J'36), Student Engr., Tubular Textile Mchy. Corp., 27 W. 20th St., New York; *for mail,* 2316 Quentin Rd., Brooklyn.
BURLEY, H. H. ('33; '35), M. E., Charge Maint., Polhemus Memorial Clinic, 350 Henry St.
BURROUGHS, Edwin E. (J'30), Ch. Engr., Charge Design, Potdevin Mch. Co., 1221—38th St.
BURT, Harold A. ('25), Mch. Designer, Mergenthaler Linotype Co., 34 Hall St., Brooklyn; *for mail,* 119-32—200th St., St. Albans, L. I.
BUSHNELL, H. C. ('13), 1215 E. 28th St.
BUTERA, Chas. N. (J'31), Serv. Engr., M. E., Kings County Buick, Inc., 44 Empire Blvd.; *for mail,* 320 Sterling St.
CALLAHAN, Jos. G. ('22; '26), Asst. Supt., Hudson Ave. Sta., Brooklyn Edison Co., Inc., Foot of Hudson Ave.; *for mail,* 6804 Narrows Ave.
CALLAHAN, Wm. J. (J'34), Inventory Dept., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail,* 302 Marine Ave.
CAMDEN, A. T. ('21; '35), Sales Engr., Stand. Oil Co. of N. Y., 21 N. 12th St., Brooklyn; *for mail,* 144-35 Northern Blvd., Flushing, L. I.
CAMERON, Hugh S. (J'25), Instr., Mech. Technology, Pratt Inst., 215 Ryerson St.
CARHART, Wilbur F. (J'35), Chief, Devel. Div., Personnel Dept., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail,* 2011 Newkirk Ave.
CHAMBERLAIN, Wm. T. ('17), 129 Columbia Heights.
CHURCH, Edwin F., Jr. ('12), Prof. M. E., Head M. E. Dept., Poly. Inst. of Brooklyn, 99 Livingston St.
CIULLA, Jos. D. (J'34), 1925—82nd St.
CLARK, E. Ernest ('29; '35), Engr., Charge Design, Dept. Correction, 160 W. Broadway, New York; *for mail,* 105 Carlton Ave., Brooklyn.
COHEN, Bernard (J'35), 721 Monroe St.
COLE, Philip H. (J'32), Draftsman & Computor, Watson-Flagg Mch. Co., 845—25th St., Paterson, N. J.; *for mail,* 44 E. 52nd St., Brooklyn, N. Y.
COLLINS, John, Jr. ('21; '28), Ch. Engr., Charge Engrg. & Opera. Utilities, Socony-Vacuum Oil Co., 400 Kingsland Ave., Brooklyn, N. Y.; *for mail,* 238—8th Ave., Paterson, N. J.
COOK, Fred L. ('31), Asst. Ch. Engr., John Robert Son Co., Inc., 133 Water St.; *for mail,* 1966 E. 21st St.
COOK, Geo. C. ('23), Oper. Dept., Steam Bur., Brooklyn Edison Co., Inc., Foot of Gold St., Brooklyn, N. Y.; *for mail,* Millington, N. J.
COOK, Hardy M. ('23), Engr. Tests, Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail,* 8950 Colonial Rd.
COONS, Horace W., Jr. (J'36), 104 St. James Pl.
COOPER, Wilbur S. ('24; '30; '35), Asst. Engr., Charge Mech. Tests, Research Bur., Brooklyn Edison Co., Inc., 55 Johnson St.
COPPERSMITH, Fred'k M. (J'33), Foreman, Natl. Lead Co., 85 Jay St., Brooklyn, N. Y.; *for mail,* 86 Isabella Ave., Newark, N. J.
COULSON, Harold H. ('32), Engrg. Dept., Am. Mch. & Fdy. Co., 5520—2nd Ave.; *for mail,* 9701 Shore Rd.
CRAWFORD, Alex. B. ('23; '35), Assoc. Mar. Engr., Design, Cent. Drafting Office, Engrg., Navy Yard, Brooklyn; *for mail,* Apt. 2D, 1253 St. Nicholas Ave., New York.
CRIMP, Geo. B. ('23; '32), M. E. Engrg. Audit, Dept. of Finance, City of N. Y., Municipal Bldg., New York; *for mail,* 52 Orange St., Brooklyn.
CROSSMAN, Albert ('03), 268 Ashland Pl.
CROWLEY, John J. ('26; '35; '35), Engr., Dept. of Water Supply, 105 W. 96th St., New York; *for mail,* 3119 Beverly Rd., Brooklyn.
CURRERI, Robt. I. (J'34), 979—42nd St.
CURRIER, Harvey L. ('22), Prin. Mar. Engr., Central Drafting Office, Engrg., Navy Yard, Brooklyn; *for mail,* 118-20—180th St., St. Albans, L. I.
CURRO, Frank Carl (J'30), 938—43rd St.
DALE, R. Burdette ('17), Supervisor, Indus. Mech. Engrg., Pratt Inst., 215 Ryerson St., Brooklyn; *for mail,* 84-21—168th Pl., Jamaica, L. I.
DASHEFSKY, Geo. J. ('30; '35), M. E., Vibration Expert, Diesel Eng. Sec,. Navy Yard.
DAVIDSON, Elmer T. (J'30), Research Engrg. Asst., A Schraders Son, Inc., 470 Vanderbilt Ave.; *for mail,* 1423 Ave. I.
DAVIDSON, Harry H. ('24; '29; '35), Ch. Engr., Charge Sales, Mullite Refractories, Seymour, Conn.; *for mail,* 9269 Shore Rd., Brooklyn, N. Y.
DAVIDSON, Ward F. ('27), Dir. Research, Brooklyn Edison Co., Inc., 55 Johnson St.
DAVY, Andrew H. (J'30), Plant Engr., Quaker Maid Co., Inc., 45 Washington St., Brooklyn; *for mail,* 6 York Pl., Merrick, L. I.
DEDRICK, Floyd F. (J'31), Jr. Engr., Plant Equip. Selection, Brooklyn Edison Co., Inc., 380 Pearl St.
DENARI, Edw. J. (J'33), 8921 Ridge Blvd.
De SOMMA, Anthony (J'35), M. E., L. J. Win[illegible] Mfg. Co., 154 W. 14th St., New York; *fo[r] mail,* 1262—38th St., Brooklyn.
DEVLIN, Edw. J. ('20), Research Engr., Brooklyn Union Gas Co., 176 Remsen St.
DOBSON, John ('23), Power Plant Engr., Am[illegible] Molasses Co., 250 Richards St.; *for mail,* 672[illegible] Ridge Blvd.
DOREMUS, Geo. A. (J'35), Asst. Engr., Mech[illegible] Engrg. Dept., Brooklyn Edison Co., Inc., 380 Pearl St., Brooklyn, N. Y.; *for mail,* 33[illegible] Marvin Ave., Hackensack, N. J.
DOUGLAS, Leon L. (J'32), 2151—76th St.
DRISCOLL, John M. (J'27), Asst. M. E., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mai[l],* 420 Clinton Ave.
DRUTMAN, Jack (J'35), 642 Lafayette Ave.
DUNCAN, Donald S. (J'36), 1810 Cortelyou Rd.
DURLACH, Marcus R., Jr. (J'33), Teacher Bd. [of] Education, City of New York, Brooklyn Tec[h.] High Sch., Brooklyn; *for mail,* 43 Walk[illegible] St., Malverne, L. I.
DWYER, John J. ('25), Sales Engr., Chimney Di[v.] M. W. Kellogg Co., 225 Broadway, New York; *for mail,* 1282 Union St., Brooklyn.
EBEL, Ralph Albert (J'36), 252—93rd St.
EDDY, Willard T. (J'33), Sales Engr., Brooklyn Union Gas Co., 176 Remsen St., Brooklyn, N. Y.; *for mail,* 23 Beech St., E. Orange, N. [J.]
EDIS, Murray A. (J'33), M. E., Meter Insp[illegible] Brooklyn Union Gas Co., E. 85th St. & Ditm[as] Ave.; *for mail,* 250 Dumont Ave.
EDMANDS, S. S. ('23), Dir., Sch. of Sci. & Tec[h.] Pratt Inst., 215 Ryerson St.
EDWARDS, G. Middleton ('16; '25; '35), [illegible] Draftsman, Kent Mch. Wks., Inc., 39 Gold S[t.] Brooklyn, N. Y.; *for mail,* 368 Hilltop Av[e.] Leonia, N. J.
EGILSRUD, F. S. ('24; '25; '35), Instr., Pr[att] Inst., 215 Ryerson St., Brooklyn; *for m[ail],* 8903—73rd Ave., Glendale, L. I.
EHRLICH, Benj. (J'36), 481 Van Buren St.
ELMORE, Chas. R. (J'34), Aviation Cadet, U.[S.] Naval Reserve, Pensacola, Fla.; *for mail,* [illegible] E. 35th St., Brooklyn, N. Y.
ELWELL, Richard Derby ('27; '34; '35), B[illegible] Supt., A. I. Namm & Co., Brooklyn; *for m[ail],* Barrett Rd., Cedarhurst, L. I.
EMBACHER, Hans R. (J'28), Research En[gr.] Dept. M. E., New York Univ., Univer[sity] Heights, New York; *for mail,* 3118 Ave. [illegible] Brooklyn.
ESSIG, Adolph F. ('21; '35), 616—61st St.

ESSIG, Wm. (J'34), 7605—10th Ave.
EVANS, Jas. N. ('28; '34; '35), Asst. Engr., Commercial Engrg. Bur., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail,* 62 Montague St.
FAAST, Frank (J'33), M. E., Diesel Eng. Design, Navy Yard.
FABER, Albert Frank, Jr. (J'36), Observer, Exper. Testing, Wright Aero. Corp., Paterson, N. J.; *for mail,* 112 Rutland Rd., Brooklyn, N. Y.
FABER, Chas. O. ('22), C. S. Hammond & Co., 440—4th Ave., New York; *for mail,* 47 Cambridge Pl., Brooklyn.
FABIROSKI, Jos. P. (J'33), 247 Vermont St.
FANGEMANN, W. Howard (J'36), 300 Sterling St.
FEDDE, Arnold M. (J'33), Draftsman, Am. Mch. & Fdy. Co., 56th St.; *for mail,* 454—9th St.
FEINER, Hyman (J'32), 2071 E. 35th St.
FEKETE, Louis A. (J'31), Jr. Engr., Charge Sta. Reports, Brooklyn Edison Co., Inc., 380 Pearl St.
FERGUSON, Donald ('31; '35), 295 Washington Ave.
FEXAS, Michael (J'35), Furrier, Vanta Bros., 345—7th Ave., New York; *for mail,* 18 Lawrence Ave., Brooklyn.
FIDELIUS, Walter R. (J'24), Sales Engr., Fitzgibbons Boiler Co., Inc., 101 Park Ave., New York; *for mail,* 135 Amersfort Pl., Brooklyn.
FIELD, Crosby ('15; '16; '21), Life Member; Pres., Flakice Corp., 360 Furman St., also V. P., Prod. & Devel., Brillo Mfg. Co., Inc., 205 Water St.
FINCH, Stanley B. ('31; '35), Supervisor & Engr., Water Heating Div., Brooklyn Union Gas Co., 180 Remsen St.
FINCKE, Donald M. ('23; '30; '35), Am. Mch. & Fdy. Co., 5502—2nd Ave.
FINKEL, J. J. ('17; '17; '35), Pres., Inter-Motor Vehicle Exchange, Inc., 76 Emerson Pl., Brooklyn; *for mail,* 221 Beach 136th St., Belle Harbor, L. I.
FITZSIMMONS, J. Harold (J'33), 1174 Sheepshead Bay Rd.
FLEISHER, Harry (J'33), 1086 Sutter Ave.
FLETCHER, Howard C. ('18), Prin. Naval Arch., Charge Design, Navy Yard.
FOGARTY, Michael J. ('14), M. E., 38-40 Harrison St.; *for mail,* 1441 Pacific St.
FOLLARI, Salvatore (J'36), Sr. Draftsman, Engr., Topographical Div., Park Dept., 80—8th Ave., New York; *for mail,* 773 Bushwick Ave., Brooklyn.
FRANK, Richard A. (J'26), Designer, J. Van Buren, 750 Grand St., Brooklyn; *for mail,* 21-19 Grand Ave., Long Island City.
FREITAG, Herman W. ('27; '35), Asst. Test Engr., Brooklyn Edison Co., Inc., Hudson Ave. Generating Sta.; *for mail,* 283 E. 43rd St.
FRIEDLANDER, Edw. A. (J'35), 125 E. 19th St.
FROLANDER, F. C. ('27), Asst. Ch. Designer, Mergenthaler Linotype Co., Ryerson St., Brooklyn, N. Y.; *for mail,* 1144 Anna St., Elizabeth, N. J.
FUERCHTGOTT, Maximilian J. ('23; '26), M. E., Design of Bridges, City of N. Y., Municipal Bldg., New York; *for mail,* 1549—46th St., Brooklyn.
GAHNKIN, Valentine G. ('22; '28), Ch. Testing Engr., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail,* 3015 Atlantic Ave.
GALATA, Richard (J'33), 1662 Cropsey Ave.
GALLAGHER, Harry J. (J'35), 7201 Ridge Blvd.
GALLO, Anthony E. (J'35), Engr., Nicholls Co., 126th St. & 91st Ave., Richmond Hill, L. I.; *for mail,* 1208 Locust Ave., Brooklyn.
GELLERT, Theo. (J'36), 1020—78th St.
GERBER, Saml. R. ('13; '21), Treas., Charge Factory Mgmt., Kent Metal Mfg. Co., Inc., 22 Morton St.
GERSONI, L. J. ('13; '35), M. E., Gen. Charge Rightway Oil Burner Corp., 40-36—82nd St., Jackson Heights, L. I.; *for mail,* 237 Parkville Ave.
GIBBONS, Jas. W. ('30), M. M., Am. Sugar Refining Co., Brooklyn; *for mail,* 111-42—170th St., Jamaica, L. I.
GIBBONS, Philip Lake (J'32), Prod. Engr., Globe Indemnity Co., 150 William St., New York; *for mail,* 223 Lenox Rd., Brooklyn.
GIBSON, F. M. ('13), Plant Engr., Am. Sugar Refining Co., 49 S. 2nd St.
GIDDINS, Saml. G. (J'36), 557 E. 94th St.
GIESL-GIESLINGEN, A. ('30; '35), Cons. Engr., 207 Ocean Ave.
GILLIE, Donald R. (J'31), Engr., Charge Matls., Arma Engrg. Co., Inc., 254—36th St.; *for mail,* 7022 Ridge Blvd.
GIVENS, Geo. C. (J'29), Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail,* 2058 E. 67th St.
GLADECK, Fred'k C. ('16; '24), Ch. Engr., Design, Am. Mch. & Fdy. Co., 5520—2nd Ave.; *for mail,* 243—80th St.
GLEESON, Wm. S. ('24; '30; '35), Maint. & Equip. Engr., Am. Mch. & Fdy. Co., 5502—2nd Ave.
GOODALE, Francis ('33; '35), Arbuckle Bros., Jay St.; *for mail,* Hotel St. George.
GORDON, Wm. (J'35), Draftsman, Arma Engrg. Co., Inc., 254—36th St., Brooklyn; *for mail,* 235 E. 53rd St., New York.
GOULD, Jack U. ('25; '32; '35), M. E., Charge Prod. & Pur., Ferdinand Gutmann & Co., 3611—14th Ave.
GRAFFEO, Jos. A. (J'35), 399 S. 4th St.
GRAHAM, Clifford T. (J'33), 15 Polhemus Pl.
GRANATA, A. J. (J'35), Engr., Charge Applied Sales, Pure Carbonic, Inc., 60 East 42nd St., New York; *for mail,* 141 E. 19th St., Brooklyn.
GRAVES, Colburn R. (J'28), Engr., Koppers Constr. Co., Maspeth Ave. & Varick St., Brooklyn; *for mail,* 73-20 Austin St., Forest Hills, L. I.
GREEN, Walter L., Jr. ('26; '35), Suptg. Engr., Luckenbach Steam Ship Co., Foot of 35th St.
GREGERSEN, John (J'29), Mch. Designer, Kingsale Dairies, 515 W. 16th St., New York; *for mail,* 237—77th St., Brooklyn.
GROSSMAN, Wm. (J'35), 99 Meserole Ave.
GUEST, Alfred Robert (J'31), Jr. Engr., Utility Consumers Serv., Inc., 470—4th Ave., New York; *for mail,* 57 Westminster Rd., Brooklyn.
GUINAN, John F. (J'30), Jr. Engr., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail,* 295 Garfield Pl.
GUS, Chas. E. (J'28), 6701 Colonial Rd.
GWILLIAM, John ('27), Pres., Gwilliam Co., 360 Furman St., Brooklyn, N. Y.; *for mail,* 8 Lenox Terrace, Bloomfield, N. J.
HAAG, Jos., Jr. ('31), Pres., Todd Combustion Equip. Inc., V. P., Robins Dry Dock & Repair Co., Foot of 23rd St.
HALL, Wm. Swanson ('25; '33; '35), Bldg. Secy., Engr., Navy Branch, Y. M. C. A., 167 Sands St., Brooklyn; *for mail,* 18 E. 10th St., New York.
HAMILTON, Wm. I. (J'35), Test Engr., Lanova Corp., 369 Lexington Ave., New York; *for mail,* 213 Eckford St., Brooklyn.
HANSEN, Max G. P. ('28), Ch. Engrg. Draftsman, Navy Yard; *for mail,* 265 Quincy St.
HARDIE, Philip H. ('23; '29; '35), Test Engr., Charge Field Tests, Brooklyn Edison Co., Inc., 55 Johnson St.
HARGEST, Wm. J. (J'30), Pratt Inst., 215 Ryerson St.
HARRINGTON, R. P. (J'35), Asst. Prof. Aero. Engrg., Poly. Inst. of Brooklyn, 99 Livingston St.
HARRIS, Herbert I. (J'34), M. E., Charge Bulk Plant, Metro. Oil Co., 32 Richardson St.
HARRIS, Murray W. ('16; '21; '35), Engr., Maint., Office of Borough President of Brooklyn; *for mail,* 755 Rogers Ave.
HARTIG, Rudolph K. ('30; '35), Asst. Testing Engr., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail,* 8813 Ridge Blvd.
HATEAU, Wm. (J'30), Draftsman & Designer, Sherron Metallic Corp., 1201 Flushing Ave., Brooklyn; *for mail,* 1530 Sheridan Ave., New York.
HATHEWAY, Philip M. ('13; '21), 220A Willoughby Ave.
HAVEMEYER, Geo. E. (J'34), 1833 E. 13th St.
HEALY, John M. ('23; '35), Design Engr., Chas. Hartmann Co., 985 Dean St.; *for mail,* 1753 Madison Pl.
HEITZ, Raymond G. (J'36), Engr., Charge Engrg. & Design, D. D. Kimball, Rm. 1728, Grand Central Terminal Bldg., New York; *for mail,* Apt. H-6, 75 Lenox Rd., Brooklyn.
HELWIG, Alfred ('16), Cons. Engr., 176 Winthrop St.
HENDERSON, Jas. ('31), Ch. Engr., Hallam Engrg. & Constr. Corp., 80 Stanhope St., Brooklyn; *for mail,* 9401 Vanderveer St., Queens Village, L. I.
HENNING, Paul F. ('31; '35), Supt., Automotive Specialty Corp., 382 Jefferson St.
HENRY, Otto H. ('20; '25; '35), Asst. Prof. M. E., Poly. Inst. of Brooklyn, 99 Livingston St.
HERLEY, Robt. J. (J'30), Toll Engrs. Dept., N. Y. Tel. Co., 101 Willoughby St.; *for mail,* 196 Clinton Ave.
HERRMANN, John F. ('18; '22; '35), Treas. & M. E., Charge Maint., Herrmann & Grace Co., 671-89 Bergen St.
HERRON, Wm. L. ('21; '32), Sales Engr., Natl. Meter Co., 4207—1st Ave., Brooklyn; *for mail,* 22 Fairview Ave., Hudson.
HERTY, Frank B. ('27; '33; '35), House Heating Supvr., Brooklyn Union Gas Co., 176 Remsen St.; *for mail,* 50 E. 18th St.
HESCHELES, Chas. A. ('25; '32; '35), Customer Serv. Div., Brooklyn Union Gas Co., 176 Remsen St., Brooklyn; *for mail,* 91-17—173d St., Jamaica, L. I.
HEYMAN, Nicholas C. (J'26), 1950 E. 15th St.
HIERS, Geo. O. ('28), Metallurgist, Natl. Lead Co., 105 York St.
HOCHMAN, Jos. L. (J'31), Engr., Charge Time Study & Methods, Jacobs Bros. Co., 26 Washington St.; *for mail,* 218—74th St.
HOLMES, Wm. C. ('21; '27), Supt. Hudson Ave., Generating Sta., Brooklyn Edison Co., Inc., 380 Pearl St.
HOOPER, Robt. P. (J'27), Testing Engr., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail,* 112 Marine Ave.
HOUGHTON, Bert ('14), Retired; 1274 E. 23rd St.
HOVGAARD, Wm. ('34), 97 Columbia Heights.
HOWARD, Geo. K. ('14), Ch. Engr., Williamsburg Power Plant Corp., 500 Kent Ave.
HUGHES, Jas. H. J., Jr. (J'31), Engr., Charge Inspec., Brooklyn Union Gas Co., E. 83rd St. & Ditmas Ave.; *for mail,* 1562 E. 31st St.
HULSMANN, J. D. (J'29), M. E., Charge Constr., E. R. Squibb & Sons, 25 Columbia Heights, Brooklyn, N. Y.; *for mail,* R. F. D. 1, Alps Rd., Paterson, N. J.
HUNTER, Arthur T. (J'23), Mgr. Sales, H. H. Bubar, 15 Park Row, New York; *for mail,* 36 Plaza St., Brooklyn.
HUNTER, Jas. W. ('25; '30; '35), Instr. M. E., Pratt Inst.; *for mail,* 45 E. 5th St.
HURLBURT, Russell B. ('23), European Mgr., Niles-Bement-Pond Co., 111 Broadway, New York; *for mail,* Granada Hotel, Ashland Pl., Brooklyn.
HUSON, Winfield S. ('87; '91), Retired; 272—6th Ave.
IRVIN, Earl H. ('34; '35), Mohawk Hotel.
ISAKSEN, Robt. C. ('21; '35), Universal Stamping Corp., 230—3rd St.
JACOBSON, Conrad C. ('17), Ch. Engr., John Robertson Co., 133 Water St., Brooklyn, N. Y.; *for mail,* 27 Douglas Rd., Glen Ridge, N. J.
JANSSEN, Henry J. (J'28), Zibold & Donohue Co., Inc., 331 Vanderbilt Ave., Brooklyn; *for mail,* 158 Forley St., Elmhurst, L. I.
JARCHO, Ralph ('28; A-M'35), Jr. Engr., Draftsman, Hiler Engrg. & Constr. Co., 122 Livingston St.; *for mail,* 1075 Linden Ave.
JENKINS, Emmons N. ('22; A'26), Commercial Engr., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail,* 3907 Quentin Rd.
JENKINS, Svend (J'30), 57 Prospect Pl.
JENSEN, Wm. Frank (J'34), Accountant, Gen. Chem. Co., 40 Rector St., New York; *for mail,* 726—68th St., Brooklyn.
JOHNSON, Jos. A. (J'36), Sales Engr., Bryant Heater Co., 230 Park Ave., New York; *for mail,* 2620 Beverly Rd., Brooklyn.
JUDSON, Harry H. ('22; '27), Dept. Asst., Brooklyn Edison Co., Inc., 380 Pearl St.
JUNG, Albert H. (J'29), Plant Engr., Charge Maint. & Design, United Am. Metals Corp., 200 Diamond St.
KENT, Robt. Sayre ('01), Pres., Engrg. Dir., Robert Sayre Kent, Inc., 383 Jay St.; *for mail,* 7616 Ridge Blvd.
KING, Williams V. (J'30), Asst. Engr., Brooklyn Edison Co., Inc., 360 Pearl St.; *for mail,* 905 E. 38th St.
KINNEY, Jos. N. (A'15), Pres. Kinney Standards, Inc. & Kinney Motors, Inc., 220 Clifton Pl., Brooklyn, N. Y.; Propr., Kinney Citrus Plantation, Val Verde, Donna, Tex.; *for mail,* 118 Quincy St., Brooklyn, N. Y.
KITT, Sam'l ('33), 352 Eastern Pkwy.
KLIGFIELD, Geo. (J'36), 8636 Bay 16th St.
KNIFFIN, Lloyd F. (J'31), Indus. Engr., Brooklyn Union Gas Co., 176 Remsen St.; *for mail,* 155—89th St.
KNIGHT, Geo. L. ('05; '08), V. P., Mech. Opera., Brooklyn Edison Co., Inc., 380 Pearl St.
KNOWLES, Richard C. (J'31), Instr., Pratt Inst., 215 Ryerson St.
KOHLER, Albert J. ('31), Engr., Inspr., Pub. Wks. Admin.; *for mail,* 9701 Shore Rd.
KOHLER, L. Frank ('21), 1778 W. 10th St.
KOLMES, Max G. (J'36), 1505 Lincoln Pl.
KROLL, Leonard A. (J'35), Machinist, N. Y., N. H. & H. R. R. Co., Readville Shops, Readville, Mass.; *for mail,* 944 E. 13th St., Brooklyn, N. Y.
KRUGMAN, Joshua (J'33), Asst. Engr., Charge Maint., Beth-El Hospital, Rockaway Pkwy. & Ave. A.
KUHN, Alfred R. ('31; '35), Engr., Charge Design, Metropolitan Engrg. Co., 1250 Atlantic Ave., Brooklyn; *for mail,* 92-47 Winchester Blvd., Queens Village, L. I.
KUHN, George W. ('22; '25), 471 Willoughby Ave.
KULICK, Sidney (J'33), Asst. Tech. Dir., Water Service Labs., 423 W. 126th St., New York; *for mail,* 1607 E. 2nd St., Brooklyn.
KUTZLEB, Richard, Jr. (J'24), Asst. Wks. Engr., Kirkman & Son, Inc., 215 Water St., Brooklyn, N. Y.; *for mail,* 275 Engle St., Englewood, N. J.
LAITMON, Jacques (J'32), Arch. & Builders Rep., Brooklyn Union Gas Co., 176 Remsen St.

LAMBERTINE, Jos. A. (J'27), Asst. Prof. M. E., Poly. Inst. of Brooklyn, 99 Livingston St.
LANDIS, Jas. N. ('25; '27; '33), Mech. Engr., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail*, 1271 E. 28th St.
LASCIAK, Chas. (J'32), Draftsman, Cent. Drafting Office, Engrg. Div., Navy Yard.
LASKOWITZ, I. B. ('30), M. E., Charge Design, Const. & Maint., Borough President's Office, Municipal Bldg.; *for mail*, 284 Eastern Pkwy.
LAUKAITIS, Albert M. (J'35), 58 Linden Blvd.
LAWRENCE, Walter Welling (J'32), Engrg. Asst., N. Y. Edison Co., Inc., Hell Gate Sta., New York; *for mail*, 254 Hancock St., Brooklyn.
LEBBAD, Anthony A. (J'33), Draftsman, Aluminum Co. of Am., Edgewater, N. J.; *for mail*, 666—55th St., Brooklyn, N. Y.
LEHMAN, Samuel (J'34), Designing Engr., De Jur-Amsco Corp., Shelton, Conn.; *for mail*, 5015—15th Ave., Brooklyn, N. Y.
LEHNER, John B. (J'30), M. E. in Test. Bur. Williamsburg Power Plant Corp., 500 Kent Ave., Brooklyn; *for mail*, 69—4th Ave., Mineola, L. I.
LENFEST, Bertram A. ('04), Dept. Head, Brooklyn Tech. High Sch., Concord & Bridge Sts.; *for mail*, 130 Sterling Pl.
LEUNIS, Robt. (J'28), Draftsman, A. Schrader's Son, Inc., Brooklyn; *for mail*, 231 St. Pauls Ave., Stapleton, S. I.
LEVERICH, Jerome W. ('19), 1815 Dorchester Rd.
LEVINE, Boris (J'34), Inspr., Am. Safety Razor Co., 315 Jay St.; *for mail*, 957 Greene Ave.
LEVINE, Nathan K. (J'31), 354—91st St.
LEVINE, Saml. (J'35), Draftsman, Bur. of Highways, Municipal Bldg.; *for mail*, 505 Georgia Ave.
LINDHARD, Sven N. (J'30), 23 Waldorf Court.
LINDSTROM, John A. ('11), Engr., Constr. & Maint., Fort Hamilton, U. S. War Dept.; *for mail*, 121 Ocean Ave.
LORD, Albert E. ('23; '35), Ch. Engr., Jos. H. Meyer Bros., 212—25th St., Brooklyn, N. Y.; *for mail*, 24 Highland Ave., Kearny, N. J.
LUNDGREN, Frank A. ('22; '35), 364—93d St.
MacDONALD, Ervin D. (J'24), Draftsman, Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn; *for mail*, 45 Covert Pl., Stewart Manor, L. I.
MacKENZIE, Norton W. (J'31), Instr., Mech. Design, Pratt Inst., 195 Grand Ave.
MACOMBER, Jas. Keith ('22; '30; '35), Engr., Charge Design, Arma Engrg. Co., Inc., 254—36th St., Brooklyn; *for mail*, 85 Andover Rd. Rockville Centre, L. I.
MAGALHAES, W. S. (J'33), Tester, Plant Tests. N. Y. Edison Co., Inc., 92 Vandam St., New York; *for mail*, 425 Grand Ave., Brooklyn.
MAGGIO, Paul Peter (J'35), Indus. Engr. Asst. Consltd. Lithographing Corp., 1013 Grand St.; *for mail*, 107 Ridgewood Ave.
MARUM, Harald (J'31), Engr., Time Study, S. H. Kress & Co., 114—5th Ave., New York; *for mail*, 958—55th St., Brooklyn.
MASINO, Frank Donald (J'34), Operation Layout Engrg., Mergenthaler Linotype Co., 43 Hall St.; *for mail*, 1024 Bedford Ave.
MAZAIKA, John (J'34), Serviceman, Brooklyn Union Gas Co., E. 85th St. & Ditmars Ave. Brooklyn; *for mail*, 65-36 Admiral Ave., Maspeth, L. I.
McARDELL, Wesley E. ('15; '20; '26), Teacher. Brooklyn Tech. High Sch., 49 Flatbush Ave. Ext., Brooklyn; *for mail*, Emerson Hill, Stapleton, S. I.
McCAUGHAN, Geo. J. (J'34), 230 Midwood St.
McCORMACK, Richard F., Jr. (J'35), 441 Ocean Ave.
McMILLAN, Alva (J'34), Asst. Pur. Agt., Arma Engrg. Co., 254—36th St.; *for mail*, Apt. C54, 196 Clinton Ave.
McPHEE, Alex. H. (J'34), Asst. to Ch. Engr., Peter Clark, Inc., 534 W. 30th St., New York; *for mail*, 152 Hendrix St., Brooklyn.
McQUEENEY, Jas. T. ('20; '25; '35), Supvr. Installations, Geo. S. May Co., 122 E. 42nd St., New York; *for mail*, 2104 Caton Ave. Brooklyn.
MEHMEL, Louis E. (J'28), Draftsman, Foster Wheeler Corp., 6 Church St., New York; *for mail*, 5513—4th Ave., Brooklyn.
MEIXELL, Keller Harold ('30; '34; '35), Maint. Engr., Valentine & Co., 369 Manhattan Ave. Brooklyn; *for mail*, 89-11—34th Ave., Jackson Heights, L. I.
MEYER, Alfred H. ('21; '27; '35), 4512 Ave. K.
MEYERS, Fred'k H. ('25; '31; '35), Mech. Asst. to Ch. of Test Bur., Williamsburg Power Plant Corp., 500 Kent Ave., Brooklyn; *for mail*, 41 Mayfair Ave., Floral Park, L. I.
MILLER, Clarence L. ('30), Treas., Miller & Van Winkle, Inc., 18 Bridge St.
MING, Fred'k W. ('18; '25; '35), Asst. Prof. of M. E., Poly. Inst. of Brooklyn, 99 Livingston St.
MIROVITCH, Eugene B. ('21), Rep. of Pres., Gen. Rep. for Latin Am., Mergenthaler Linotype Co., 29 Ryerson St.
MOORE, Wm. James ('18), Prof. Exper. Engrg., Poly. Inst. of Brooklyn, 99 Livingston St.
MORRIS, Edw. A. (J'35), 527 Bushwick Ave.
MOSHER, Fred D. (J'36), M. E. Inspr., Hartford Steam Boiler Inspc. & Ins. Co., 90 John St., New York; *for mail*, 952 St. Marks Ave., Brooklyn.
MOTT, E. Parker ('29; '35), M. M., Metal Hose & Tubing Co., Brooklyn; *for mail*, 9460—224th St., Queens Village, L. I.
MUELLER, Karl Wm. (J'32), Supt.'s Asst., Brooklyn Union Gas Co., Maspeth & Varick Aves., Brooklyn, N. Y.; *for mail*, 138—49th St., Union City, N. J.
MULLEN, Chas. A. ('27; '35), M. E., Brooklyn Edison Co., 380 Pearl St., Brooklyn; *for mail*, 9509—117th St., Richmond Hill, L. I.
MURPHY, Robt. Jos. (J'27), Asst. Engr., Operating Dept., Brooklyn Edison Co., Inc., 380 Pearl St., Brooklyn, N. Y.; *for mail*, 133 Claremont Ave., Jersey City, N. J.
NAGEL, Theo. ('18), Cons. Engr., 50 Orange St.
NAPIER, Alex. E. (J'28), Bldg. Secy., Pur. & Maint., Navy Y. M. C. A., 167 Sands St.
NAPP, Julius L. (J'33), Sperry Gyroscope Co., Inc., Manhattan Bridge Plaza, Brooklyn; *for mail*, 11918—107th Ave., Richmond Hill, L. I.
NEDERMAN, Malte R. ('25; '31; '35), Designing Engr., Am. Mch. & Fdy. Co., 5520—2nd Ave.; *for mail*, 855—51st St.
NEILSON, Edward J. (J'33), 221—79th St.
NELIS, Jos. J. ('14), V. P., Foster Wheeler Corp., 165 Broadway, New York; *home address*, 1017 E. 26th St., Brooklyn.
NELSON, Seddon C. (J'34), Engrg. Dept., Hauck Mfg. Co., 126—10th St.
NEUSCHAFER, Geo. A. (J'36), 235 E. 31st St.
NIPER, Louis S. (J'25), Real Estate, 193 Joralemon St.; *for mail*, 57 Sterling St.
OFFENHEISER, Chas. M. (J'33), Assembly Mech., Arma Engrg. Co., Inc., Bush Term., 36th St., Brooklyn, N. Y.; *for mail*, 257 Liberty Ave., Jersey City, N. J.
OILL, Benj. C. (J'34), Estimating Engr., Carrier Corp., 850 Frelinghuysen Ave., Newark, N. J.; *for mail*, 699 Madison St., Brooklyn, N. Y.
OLIKER, Herman ('36), M. E., Charge Design & Opera., Naturalux Products Corp., 444—12th St.; *for mail*, 2061 Homecrest Ave.
OLIVER, B. H., Jr. (J'28), Supvrg. Engr., N. Y. Tel. Co., 101 Willoughby St.; *for mail*, 535—75th St.
OLSCHWANG, Morris J. ('23; '31; '35), Ch. Engrg. Draftsman, Navy Yard; *for mail*, St. George Hotel.
ONDERDONK, Paul T. ('27; '36), Asst. Plant Equip. Engr., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail*, 9115 Colonial Rd.
O'NEIL, Chas. H. (J'36), Asst. Mech. Constr. Engr., Brooklyn Edison Co., Inc., 380 Pearl St.
PAINE, Arthur P. ('20; '35), Dir. Patents, Mergenthaler Linotype Co., 29 Ryerson St.
PAUKNER, Frank J. (J'29), Die & Tool Designer. E. W. Bliss Co., 53rd St. & 2nd Ave., Brooklyn; *for mail*, 87-82 Parsons Blvd., Jamaica, L. I.
PENNELL, Donald F. (J'29), Jr. Engr., Brooklyn Edison Co., Inc., 380 Pearl St., Brooklyn, N. Y.; *for mail*, 318 E. 59th St., Seattle, Wash.
PEROTTO, Ribelle (J'30), Engr., Interborough Engrg. Co., 154 Lawrence St.
PETER, Walter J. ('21; '35), Asst. Supt., Brooklyn Union Gas Co., 176 Remsen St.; *for mail*, 200 E. 19th St.
PETERS, Edmund (J'27), Mech. Designer, C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn; *for mail*, 102-26 Van Wyck Blvd., Richmond Hill, L. I.
PETERSON, Geo. E. (J'28), Asst. Engr., Opera., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail*, 33 Argyle Rd.
PETERSON, Harold, Jr. (J'35), Student Engr., Gen. Elec. Co., 5 Lawrence St., Bloomfield, N. J.; *for mail*, 1648 Madison Pl., Brooklyn, N. Y.
PHALEN, Jas. J. ('23; '35), Indus. Engr., Mergenthaler Linotype Co., 29 Ryerson St.
PHILLIPS, Leo A. ('23), Cons. Engr., 21 E. 21st St.
PIESEN, Robt. (J'36), 160 E. 15th St.
POTTER, Arthur W. (A'32), Gen. Mgr., Ptg. & Supply Dept., Great Atlantic & Pac. Tea Co., 75 Front St., Brooklyn; *for mail*, 102-37—85th Rd., Richmond Hill, L. I.
PRASS, Herman (J'26), Elec. Designer, Lummus Co., 50 Church St., New York; *for mail*, 135 Prospect Pk., S. W., Brooklyn.
PRAY, Chas. F. (J'31), Inventory Dept., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail*, 3311 Ave. P.
PROZAN, Moses ('36), 1845 E. 19th St.
PUTNAM, John L. (J'32), Engr., Oper. Div., Arbuckle Bros., Pearl St.; *for mail*, 89 Celeste Court.
PUTNAM, Linwood J. (J'36), Engr., Opera. & Maint., Vanderbilt Hotel, 4 Park Ave., New York; *for mail*, 2047 Nostrand Ave., Brooklyn.
QUIER, K. E. ('33; '35), Instr. Mech. Tech., Pratt Inst., 215 Ryerson St.
RAHM, Fred'k W. ('25; '35), Designer, Cameron Mch. Co., 67 Poplar St., Brooklyn; *for mail*, 2916 Greene Pl.
RASMUSSEN, Find ('13), 7807—12th Ave.
REMESCHATIS, Ralph E. (J'35), Cadet Engr., Brooklyn Union Gas Co., 176 Remsen St.; *for mail*, 521 Bainbridge St.
RENNIE, John A. ('21), Supt., Ch. Engrg., Boorum & Pease Co., 192 Front St., Brooklyn; *for mail*, 130-45—226th St., Laurelton, L. I.
RETZ, Andrew M. (J'36), Jr. Engr., Oil Burner Div., Todd Combustion Equip., Inc., Foot of 23d St., Brooklyn; *for mail*, 187 River Rd., Grand View on Hudson, Nyack.
REUSCH, Victor M. (J'30), Teacher, Brooklyn Tech. High Sch., Flatbush Ave. Ext.; *for mail*, 406 Madison St.
RICHMOND, Julian ('03; '08; '19), Pres., Potdevin Mch. Co., 1221—38th St., Brooklyn; *for mail*, 71 Dunwoodie St., Yonkers.
RICHMOND, Julius D. ('24; '25; '35), Draftsman, Brooklyn Manhattan Transit Corp.; *for mail*, 390 Parkside Ave.
RIKER, Edw. (J'36), Cadet Engr., Brooklyn Union Gas Co., 176 Remsen St., Brooklyn; *for mail*, 9920—203d St., Hollis, L. I.
RIZZUTO, Alfonso ('29; '31; '35), Draftsman, Wks. Progress Admin., Municipal Bldg.; *for mail*, 1833 W. 13th St.
ROBBINS, Harris A. ('15), Supt. Power, Brooklyn-Manhattan Transit Corp., 385 Flatbush Ave. Ext.
ROBERTSON, Norman F. (A'30), Pres., John Robertson Co., Inc., 133 Water St.
ROEDE, Chas. B. (J'29), Engr., Charge Maint., Sperry Products, Inc., Manhattan Bridge Plaza, Brooklyn, N. Y.; *for mail*, 901 Ray Ave., Ridgefield, N. J.
ROMIGH, Orin L. (J'34), Engr., Natl. Meter Co., 42nd & 1st Ave.; *for mail*, 55 Hansen Pl.
ROWLAND, Thos. F., Jr. ('84), 190 New York Ave.
ROWLEY, Louis N., Jr. (J'31), Jr. Engr., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail*, 1120 Bergen St.
RUPP, Manning E. ('09; '13; '19), 710 Ave. V.
SAHRBECK, Chas. J., Jr. (J'34), 1116 E. 15th St.
SCANLON, Harry Charles (J'36), 245 Sterling St.
SCHAAF, Geo. C. (J'36), Layout Man, Draftsman Columbia Steel Rule Die Corp., 270 Lafayette St., New York; *home address*, 66-51 Freshpond Rd., Ridgewood, Brooklyn.
SCHAPIRO, Paul (J'33), Jr. Engr., 330 Hinsdale St.
SCHEIN, Alex ('18; '19), V. P., Charge Mfg., Sperry Gyroscope Co., Inc., Manhattan Bridge Plaza.
SCHELL, Horace B. ('26), Design Engr., Internatl. Ptg. Ink Corp., 432 W. 45th St., New York; *for mail*, 216 Park Place, Brooklyn.
SCHENCK, Teunis (J'29), Engrg. Asst., 1st Grade, Inventory, Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail*, 255 E. 18th St.
SCHICK, Herman L. (J'34), 234 Cornelia St.
SCHMIDT, Fred W. (J'35), Engr., Design, Markwell Mfg. Co., 200 Hudson St., New York; *for mail*, 257 Linden St., Brooklyn.
SCHMIDT, Harry Paul (J'30), Instr., Dept. of Physics, Engrg. School, Pratt Inst., Ryerson St.; *for mail*, 5 Clifton Pl.
SCHRECKENBERGER, Edw. (J'36), 4916—4th Ave.
SCHULTZ, Rudolph H. ('27; '31), Pres., Schultz Engrg. Corp., 25 Stanwix St.
SCHWARTZ, Frank L. ('28; '35), Instr., Pratt Inst.
SCHWEIZER, Chas. L. (J'20), N. Y. Steam Corp., 4 Irving Pl., New York; *for mail*, 431—82nd St., Brooklyn.
SCHWIND, Geo. (J'29), M. E. Charge Opera. & Maint., Loew's Oriental Theatre, 18th Ave. & 86th St.; *for mail*, 2338 E. 23rd St.
SCOTT, John W. ('07), Gen. Supt., Arbuckle Bros., Foot of Jay St., Brooklyn, N. Y.; *for mail*, Appomattox, Va.
SEAMAN, Henry B. ('96), Life Member; Cons. Engr., 51 Quincy St.
SELTS, Wm. A. ('30), 982 E. 38th St.
SENTER, Carl A. ('21; '25), Retired; 214 Prospect Pl.
SETCHELL, John E. ('21; '32), Asst. Prof. M. E., Poly. Inst. of Brooklyn, 99 Livingston St.
SETCHELL, John Stanford (J'35), Asst. to Utilization Engr., Am. Gas Assn., 420 Lexington Ave., New York; *for mail*, 1219—63rd St. Brooklyn.
SETHER, John A. ('27; '35), Ch. Engr., Hotel St. George, 51 Clark St.; *for mail*, 8202—10th Ave.
SEYFRIED, Carl L. (J'29), 582 Triton Ave., Coney Island.

SHERMAN, Waldo L. ('16; '25), Secy. & Treas., Charge Sales, John Robertson Co., Inc., 133 Water St.
SHOOR, Sam (J'35), Engrg. Estimator, Carrier Corp., 850 Frelinghuysen Ave., Newark, N. J.; *for mail*, 1623 Dahill Rd., Brooklyn, N. Y.
SILBER, Victor (J'33), 224 E. 56th St.
SKROTZKI, Bernhardt G. A. (J'29), Jr. Engr., Brooklyn Edison Co., Inc., 380 Pearl St., Brooklyn; *for mail*, 83-15—118th St., Kew Gardens, L. I.
SMITH, Chas. E. ('21; '35), Asst. Engr., Brooklyn Edison Co., Inc., 380 Pearl St., Brooklyn; *for mail*, 48 Cumberland, Rockville Centre L. I.
SMITH, Donald A. (J'33), Foreman, Varnish Dept., F. H. Levey Co., Inc., 222—44th St.
SMITH, Ed. Sinclair, Jr. ('23; '31), *Junior Award*, '30; M. E. Charge Patents, C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn; *for mail*, 114-57—176th St., St. Albans, L. I.
SMITH, Hartley LeH. ('28), Ch. Engr., Testing Bur., Williamsburg Power Plant Corp., 500 Kent Ave.
SMITH, Theodore H. (J'29), Asst. Sta. Effic. Engr., Charge Power Plant Testing, etc., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail*, 103 Pierrepont St.
SOLOV, A. (J'32), Engr. Draftsman, Cent. Drafting Office, Engrg., Navy Yard; *for mail*, 172½ Lee Ave.
SPERRY, Edw. G. (A'22), V. P., Sperry Products, Inc., Manhattan Bridge Plaza; *for mail*, 155 Henry St.
SPERRY, Elmer A., Jr. ('29), V. P., Sperry Products, Inc., Manhattan Bridge Plaza.
SPIEVAK, Jos. (J'34), 194 Columbia Heights.
STACK, Donald P. (J'31), 77 Richmond St.
STAHL, Edw. C. M. ('26), Oper. Supt., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail*, 167—76th St.
STAPLES, Frank C. (J'36), Plant Engr., Am. Molasses Co., 280 Richards St., Brooklyn; *for mail*, 168 Aspen St., Floral Park, L. I.
STAVER, Edw. F. (J'28), Secy., Sales Design. Engrg., Fred Goat Co., Inc., 314 Dean St., Brooklyn; *for mail*, 3721—79th St., Jackson Heights, L. I.
STEILEN, Louis J. (J'34), 2234 Homecrest Ave.
STEINBERG, Howard G. (J'36), Engr., Charge Design, Concord Burner Co., Inc., 1 Hanson Pl.
STEINMAN, Geo. (J'35), Draftsman, Dept. of Parks, 46th Ave. & 111th St., Corona, L. I.; *for mail*, 631 Hegeman Ave., Brooklyn.
STERN, Isaac ('27), Pres., S. & S. Corrugated Paper Mchy. Co., Inc., 160 N. 4th St., Brooklyn; *for mail*, 441 West End Ave., New York.
STEWART, Jas. A. ('27), Engr., Sales & Serv., Air Preheater Corp., 60 E. 42nd St., New York; *for mail*, 166 Hicks St., Brooklyn.
STEWART, John A. (J'29), Testing Bur., Williamsburg Power Plant Corp., 500 Kent Ave.; *for mail*, 2591 Bedford Ave.
STILES, Linford S. ('24), Constr. Engr., Brooklyn Union Gas Co., 176 Remsen St.
STOELTZING, Harry E. ('16), Asst. Supt., Power Const. & Opera., Brooklyn-Manhattan Transit Corp., 385 Flatbush Ave. Ext.
STOELZER, Walter H. ('21; '23; '35), 148 Rodney St.
STONE, Mason A. ('07; '21), Sr. Engr., Charge Estimating Dept., Wks. Progress Admin., Dept. of Hospitals, 109 Cumberland St., Brooklyn; *for mail*, Shelton Hotel, 49th St., & Lexington Ave., New York.
TRADER, Roland H. ('15; '23), Asst. Supt., Opera. & Maint., Consltd. Edison Co., Astoria, L. I.; *for mail*, 710 Chauncey St., Brooklyn.
TRAUB, Geo. H. (J'30), Asst. to Supt., Distribution Dept., Brooklyn Union Gas Co., 176 Remsen St.; *for mail*, 78 Highland Pl.
TURKEN, Carl A. ('13; '26), Ch. Engr., Supt., Arbuckle Bros., Foot of Jay St.
AG, Walter ('15; '19; '24), Engrg. Dept., Knickerbocker Ice Co., 41 E. 42nd St., New York; *for mail*, 786 E. 38th St., Brooklyn.
APLINGER, Jean R. (J'33), 825 E. 18th St.
HOMPSON, Clyde ('19; '23; '35), M. E., Opera. & Maint., Hugo Brand Leather Co., 157—13th St.; *for mail*, 8301—12th Ave.
HOMSON, Wallace G. (J'33), 496—7th St.
HORNLEY, Robt. F. (J'30), Jr. Matl. Engr., Matl. Lab., Navy Yard; *for mail*, 233 Quincy St.
ODD, Jas. Herbert ('30), Pres., Todd Dry Dock Engrg. & Repair Corp.; *for mail*, 109 Maple St.
ORREGROSSA, Salvatore ('33), Engr., Engrg. Inspc., Dept. of Health, 131 Water St., New York; *for mail*, 777 Bushwick Ave., Brooklyn.
OWNSEND, Wisner R. ('27; '35), Asst. Wks. Engr., Chas. Pfizer & Co., Inc., 11 Bartlett St.; *for mail*, 372 Clermont Ave.
RAVER, Alfred E. (J'30), Lab. Technician, Socony-Vacuum Oil Co., Inc., 412 Greenpoint Ave.; *for mail*, 99 Meserole Ave.
TROY, Max ('32; '35), Ch. Engr., Gen. Linen Supply & Laundry Co., Inc., 835 Myrtle Ave.
TUCKER, Stanley A. (J'36), Div. Engr., M. E. Dept., Brooklyn Edison Co., Inc., 380 Pearl St.; *for mail*, 1729 Stuart St.
VANE, Francis F. (J'34), Steam Tester, Williamsburgh Power Plant Corp., 500 Kent Ave., Brooklyn; *for mail*, 338 E. 67th St., New York.
VIOLA, Bartholomew ('01), 57 Lincoln Rd.
VITALE, Renato L. (J'36), Jr. E. E., Design. Supervision & Inspection, Bd. of Transportation, 250 Hudson St., New York; *for mail* 366 Ave. T, Brooklyn.
WAGNER, Arno (J'34), Gen. Foreman, Globe Collapsible Tube Corp., 28 Columbia Heights.
WAGNER, Jackson J. ('21; '29; '35), Ch. of Supply, Borough of Brooklyn, Wks. Progress Admin.; *for mail*, 903 Lenox Rd.
WALDRON, J. Laurence ('15; '35), 652a Lafayette Ave.
WALKER, Harold L. ('30; '35), Factory Mgr., Esmco Auto Products Corp., 33—34th St.; *for mail*, 7001 Ridge Blvd.
WALLACE, A. L. ('30), Ch. Engr., Metal Hose & Tubing Co., 253 Tillary St.
WALTER, Hans. W. ('34; '35), Asst. Engr., Brooklyn Edison Co., Inc., 380 Pearl St., Brooklyn; *for mail*, 209-26 Bardwell Ave., Queens Village L. I.
WALTON, Earle ('21; '35), Order Interpreter Westinghouse Elec. & Mfg. Co., 1180 Raymond Blvd., Newark, N. J.; *for mail*, 848 E. 28th St., Brooklyn, N. Y.
WARING, Robt. W. (J'30), Engr., Sperry Gyroscope Co., Manhattan Bridge Plaza.
WEBER, Philip Francis (J'26), Engr., Prod., Design & Exper., Kollsman Instrument Co., 1 Junius St.
WEBSTER, Daniel J. (J'36), Training, Koppers Coke Co., 16 Court St., Brooklyn; *for mail* 35 Ten Broeck St., Albany.
WEIR, Geo. E. (J'27), Asst. Engr., Plant Equip. Bur., M. E. Dept., Brooklyn Edison Co., Inc., 380 Pearl St., Brooklyn; *for mail*, 8528—118th St., Richmond Hill, L. I.
WEISS, Louis T. ('13; '25), Owner, Louis T. Weiss. Screw Mch. Products, 772 Pacific St.
WELLBROCK, Richard (J'36), 548—74th St.
WELLS, Walter F. ('14), 458 Washington Ave.
WESHLER, Albert (J'34), 282 Grand Ave.
WEYER, L. O. ('21; '35), Instr., Dept. of M. E., Poly. Inst. of Brooklyn, 99 Livingston St.
WHALLON, Jas. E. ('27; '34; '35), Mech. Constr. Engr., Brooklyn Edison Co., Inc., 380 Pearl St.
WHITE, Weston B. (J'36), Asst. Inventory Supvr. Brooklyn Edison Co., 380 Pearl St.; *for mail* 131—78th St.
WHITLEY, Lieut. Col. Frederic N. ('14), Pres. Charge Engrg., Frederic N. Whitley, Inc., 173 Pacific St.
WICHUM, Victor ('16; '21), Ch. Engr., Sales Engrg. Dept., C. J. Tagliabue Mfg. Co., Park & Nostrand Aves.; *for mail*, 1291 Dean St.
WILLIAMS, Louis W. ('12; '25), Cons. Engr., 219 Clinton Ave.
WINES, Harry Thomas (J'32), 5207 Ave. M.
WISEMAN, Elton J. (J'27), Div. Engr., Plant Equip. Bur., Brooklyn Edison Co., Inc., 380 Pearl St.
WISEMAN, John T. ('19; '22), Plant Mgr., Morse Plant, United Dry Docks, Inc., Foot of 56th St.
WITHERS, Cleeman ('26; '35), Treas., Sperry Gyroscope Co., Inc., 40 Flatbush Ave. Ext.
WOODMAN, Walter C. ('29; '36), 997 E. 18th St.
WUNSCH, Jos. W. ('17; '23; '27), Pres., Ch. Engr., Silent Hoist Winch & Crane Co., 762 Henry St.
YESOWITZ, Max (J'36), Sales Engr., Vibration Eliminator Co., 41-26—37th St., Long Island City; *for mail*, 581 Linwood St., Brooklyn.
ZEITZOFF, Saml. (J'36), 1836—66th St.
ZOBER, Walter ('27; '34; '35), Head, Drafting Div., Arma Engrg. Co., 254—36th St.; *for mail*, 7201—4th Ave.
ZOURAEFF, Ali-Khan ('27; '35), 157 E. 8th St.

BUFFALO, Buffalo Section

ABRAHAMSON, Edwin W. ('30; '35), Pres. Abrahamson Corp., 481 Winspear Ave.
ARMSTRONG, Wm. M. ('94; '16), V. P., Merckens Chocolate Co., Inc., 506-520—7th St.
BARNES, Eugene L. ('16), 168 Crescent Ave.
BARRETT, Edw. L. (J'34), Service Opera., Cellophane Div., E. I. du Pont de Nemours & Co.; *for mail*, 194 Chadduck Ave.
BASSETT, Geo. B. ('14), Pres., Gen. Mgr., Buffalo Meter Co., 2917 Main St.; *for mail*, 691 W. Ferry St.
BAUSCH, Edward (Non-Member), *A. S. M. E. Medallist*, '36; Bausch & Lomb Optical Co.
BAXTER, Allan H. ('27), Designing & Cons. Engr., A. E. Baxter Engrg. Co., 344 Delaware Ave.
BAXTER, Edw. Dows (J'36), 344 Delaware Ave.
BERTSCH, John C. ('01), Designer, Worthington Pump & Mchy. Corp., Clinton St. & Roberts Ave.; *for mail*, 340 Richmond Ave.
BIERBAUM, Christopher H. ('94; '98), Life Member; V. P., Cons. Engr., Lumen Bearing Co., 197 Lathrop St.
BIRK, Paul M. (J'34), Draftsman, Curtiss Aeroplane Div., Curtiss-Wright Corp., Buffalo; *for mail*, 307 Delaware Rd., Kenmore.
BOHN, Gerhardt H. ('28), Designing Engr., Linde Air Products Co., 155 Chandler St., Buffalo; *for mail*, 189 Westgate Rd., Kenmore.
BOOTH, Chas. A. ('09), V. P., Charge Sales, Buffalo Forge Co., 490 Broadway, P. O. Box 985.
BOOTH, Daniel M. ('33), Worthington Pump & Mchy. Corp.; *for mail*, Hotel Stuyvesant.
BROHL, Harry T. ('26; '35), Steam Engr., Westinghouse Elec. & Mfg. Co., Buffalo; *for mail* 76 Washington Highway, Snyder.
BUERK, Benj. C. (J'31), Supt., Buerk Tool Wks., 315 Grote St.; *for mail*, 46 Elmview.
BURGESS, Donald ('34; '35), Asst. Supvg. Oper., Buffalo Gen. Elec. Co., Elec. Bldg.; *for mail*, 269 Lisbon Ave.
BURTT, Nelson W. ('23; '33; '35), Project Engr., Charge Stand., Rayon Dept., E. I. du Pont de Nemours & Co., Sta. B.
CADY, Edw. F. (J'35), Sales Engr., Blower Corp., White Bldg.
CASE, Melville C. (J'34), Jr. Engr., Natl. Aniline & Chem. Co.; *for mail*, 412 St. Lawrence Ave.
CRAMER, John L. (J'36), Engr. in Training Linde Air Products Co., 169 Chandler St.; *for mail*, 176 Southampton St.
CRANE, Robt. L., Jr. (J'31), Warehouse, Metal Working Mchy., Iroquois Mchy. Co., 658 Ohio St., Buffalo; *for mail*, 110 Columbia Dr. Williamsville.
CREWSON, Geo. G. ('15; '19), Partner, Cons. Engr., Indus. Equip. Co., 306 Jackson Bldg.; *for mail*, 97 Huntington Ave.
CROLL, Raymond H. ('26; '32; '35), Asst. Mgr., Compressor Dept., Worthington Pump & Mchy. Corp.
CURRIER, Chas. H. ('18; '35), V. P. & Gen. Mgr., Ross Heater & Mfg. Co., Inc., 1407 West Ave.
CUSHING, H. M. ('22), Ch. Engr., Buffalo Gen. Elec. Co., 39 E. Genesee St.; *for mail*, 149 Commonwealth Ave.
DEVERALL, Chas. N. ('24; '35), Engr., Niagara Blower Co., 673 Ontario St.; *for mail*, 71 Highgate Ave.
DIADDARIO, Alexander N. (J'32), Draftsman. Spencer Lens Co., 19 Doat St.; *for mail*, 511 Northland Ave.
DOLLAR, W. M. ('96; '03), Cons. Engr., Mgr. Buffalo Office, Warsaw Elev. Co., 64 Delaware Ave.
DOWNING, John C. ('28; '34; '36), Control Engr., Charge Maint., C. R. Huntley Sta., Buffalo Gen. Elec. Co., Buffalo; *for mail*, 30 Pullman Ave., Kenmore.
DUBOSCLARD, Paul ('33), Pres. & Gen. Mgr., Farnham Mfg. Co., 1646 Sececa St.
DUFFEY, Paul R. ('36), 270 Michigan Ave.
ECKSTROM, Albert W. (J'35), Designing Engr. Buffalo Fdy. & Mch. Co., 1543 Fillmore Ave.; *for mail*, Hotel Stratford Arms, 25 W. Utica St.
ESPIG, Erwin E. ('28; '34; '35), Field Engr. Buffalo, Niagara & East. Power Corp., Elec. Bldg., Buffalo; *for mail*, 284 Nassau Ave., Kenmore.
EVARTS, Howard M. ('23; '33), M. E., Div. of Bldg., City of Buffalo, New City Hall Bldg.; *for mail*, 675 Richmond Ave.
FABER, Otto ('22), Ch. Engr., G. L. Squier Mfg. Co., 490 Broadway.
FAILMEZGER, Victor H. (J'29), Worthington Pump & Mchy. Corp., Clinton St.
FARNHAM, Bion B. ('18), Gen. Mgr., Farnham Mfg. Co., 31-39 Indiana St., Buffalo; *for mail* 55 E. Hazeltine Ave., Kenmore.
GAMBERT, Geo. Walter (J'33), Power Sec., Rayon Dept., E. I. du Pont de Nemours & Co.; *for mail*, 821 Elm St.
GIBBY, Wm. F. (J'34), 125 North St.
GIBSON, Norman R. ('27), V. P., Charge Engrg., Buffalo, Niagara & East. Power Corp., Elec. Bldg.
GILLIG, Geo. J. (J'34), 1011 Walden Ave.
GODFREY, Wm. G. ('34; '36), Field Engr., Buffalo Gen. Elec. Co., Elec. Bldg.; *for mail* 224 Hartwell Rd.
GRACE, Wm. A. ('27), Ch. Engr., Larkin Co., Inc.; *for mail*, 251 Woodlawn Ave.
GRAF, Oscar A. (J'31), Engr., Wittemann Co., Inc., 842 Elk St.; *for mail*, 121 Claremont Ave.
GREEN, John S. ('19; '24), Supt., Charge Mfr., Ross Heater & Mfg. Co., 1407 West Ave.
GRIFFIN, W. A. ('20), Exec. V. P., Stand. North Buffalo Fdys., Inc., 743 Hertel Ave.
GUEST, J. Russell (J'31), Process Engr., Dye Dept., Natl. Aniline & Chem. Co., 351 Abbott, Buffalo; *for mail*, 23 Clinton Ave., Fredonia.
HARDING, Louis A. ('13), Pres., L. A. Harding Constr. Corp., 612 Prudential Bldg.

HARRINGTON, Carlos E. ('26), Asst. Prof. & Asst. to Dean, Univ. of Buffalo, 3435 Main St.; *for mail,* 52 Winter St.
HART, Frank M. (J'35), Safety Engr., Fidelity & Casualty Co. of N. Y., 414 Ellicott Sq.
HARVEY, Earland E. ('31; '35), 98 Alsace Ave.
HELFTER, Franklin S. ('34), Engr., Mech. Design, Buffalo Gen. Elec. Co., Elec. Bldg.
HINMAN, Nelson P. ('27; '35), Supt. Power House, Pierce Arrow Motor Corp., 1695 Elmwood Ave.; *for mail,* 25 Colfax Ave.
HIRSCHMAN, Wm. F. ('30), Pres. & Treas., W. F. Hirschman Co., 220 Delaware Ave.
HUBBELL, Brig.-Gen. Lyman P. ('15), Partner, Darling & Hubbell, 6 Arlington Pl.
HUGHES, Burton S. ('08), Pres., Zaremba Co., 506 Crosby Bldg.; *for mail,* 857 Delaware Ave.
HUGHES, John Stanley ('27; '35), Chem. Engr., Zaremba Co., 506 Crosby Bldg.
HYMAN, D. ('92), V. P., Empire Limestone Co., 621 Genesee Bldg.
JACOBS, John J., Jr. (J'34), Jr. Engr., Power Dept., Natl. Aniline & Chem. Co., 351 Abbott Rd.; *for mail,* 138 Elmwood Ave.
JAMES, W. A. ('15), Ch. Engr., Maint. & Design, Bethlehem Steel Co., Hamburg Turnpike, Lackawanna; *for mail,* 314 Norwood Ave., Buffalo.
KAUFFMANN, Wm. M. (J'32), M. E., Diesel Eng. Div., Worthington Pump & Mchy. Corp., Clinton St. & Roberts Ave.; *for mail,* 129 Groveland Ave.
KEIL, Elmer F. ('34; '35), M. M., C. R. Huntley Stas., Buffalo Gen. Elec. Co., Elec. Bldg.; *for mail,* 27 Condon Ave.
KEISER, Rufus Dale (J'36), 125 W. North.
KERKER, Henry F. ('28; '35), Engr., Buffalo Fdy. & Mch. Co., 1543 Fillmore Ave.; *for mail,* 35 Fernhill Ave.
KERMER, Martin J. ('14), Ch. Engr., Buffalo Fdy. & Mch. Co., 1542 Fillmore Ave.; *for mail,* 41 Burke Dr.
KESSLER, Armin G. ('09; '25), V. P., Gen. Mgr., Farrel-Birmingham Co., Inc., 344 Vulcan St.; *for mail,* 96 Bidwell Pkwy.
KEYES, Henry Morgan (J'36), Testing Engr., Farrel-Birmingham Co., Inc., 344 Vulcan St.
KIPLINGER, C. Gale (J'21), Maint. Supvr., Natl. Aniline & Chem. Co., 351 Abbott Rd., Buffalo; *for mail,* 203 Washington Highway, Snyder.
KRATZER, Jas. C. (J'35), M. E., Exper. Labs., Linde Air Products Co., 169 Chandler St.; *for mail,* 61 Days Pk.
LEHN, Henry C. ('15; '35), Ch. Engr., Snow Wks., Worthington Pump & Mchy. Corp.; *for mail,* 30 Morris Ave.
LINNENBRUEGGE, Hans ('28), Designer, Gas & Oil Engs., Worthington Pump & Mchy. Corp.; *for mail,* 40 Oschawa Ave.
MADISON, Richard D. ('18; '35), Research Engr., Buffalo Forge Co., 490 Broadway.
MANGER, Paul A. (J'21), Ch. Draftsman, Farrell-Birmingham Co., Inc., 344 Vulcan St., Buffalo; *for mail,* 117 South Drive, Eggertsville.
McCANNA, F. Jas. (J'31), Supt., Charge Prod., U. S. Rubber Reclaiming Co., Babcock & Hanna Sts.; *for mail,* 43 Liberty Terrace, Sta. H.
McCANNA, Louis A. (J'32), Worthington Pump & Mchy. Corp., P. O. Box 953; *for mail,* 347 E. Ferry St.
MENSONIDES, Sjoerd ('22), V. P., Charge Engrg., Farrar & Trefts, Inc., 9 Grimes St.
MILLER, Wm. A. (J'21), Designer, Columbus McKinnon Chain Corp., Tonawanda; *for mail,* 62 Benwood Ave., Buffalo.
MOORE, Raymond P. ('27), Engr., Charge Mech. Design, Buffalo, Niagara & East. Power Corp., Elec. Bldg., Buffalo; *for mail,* 242 Knowlton Ave., Kenmore.
MORRIS, Wm. Chester ('20; '35), Project Engr., Tech. Div., E. I. du Pont de Nemours & Co., Sta. B, Buffalo; *for mail,* R. F. D. 2, Main Rd., Clarence.
MUNSCHAUER, Geo. R. ('20; '27), Pres. & Gen. Mgr., Niagara Mch. & Tool Wks., 638 Northland Ave.
NEAL, John R. H. ('15), Mem. Firm, Root Neal & Co., 178 Main St.
NELSON, Harold A. (J'35), 277 E. Utica St.
NELSON, Swen W. ('20; '26), Mgr. Buffalo Branch, Bailey Meter Co., 705 Ellicott Sq.
NEUBAUER, Geo. A. ('18; '35), Asst. Ch. Engr., Consltd. Packaging Mchy. Corp., 1400 West Ave.; *for mail,* 339—15th St.
NICHOLSON, Ezra K. ('24; '34), Sr. Project Engr., Natl. Aniline & Chem. Co., 351 Abbott Rd.; *for mail,* 1149 Delaware Ave.
ORNO, Knud E. ('27), Engr., Charge Design, Rayon Dept., E. I. du Pont de Nemours & Co., Sta. B, Buffalo; *for mail,* 42 Chapel Rd., Kenmore.
OSGOOD, John L. ('98), Prop., J. L. Osgood Tool Co., 43 Pearl St.
PANCOAST, J. D. ('16; '35), Zaremba Co., 506 Crosby Bldg.; *for mail,* 116 Congress St.
PARKER, Karr ('18; '20; '24), Pres., McCarthy Bros. & Ford, 75 W. Mohawk St.; *for mail,* 234 Depew Ave.
PHELPS, Arthur S. ('30), Engr., Pratt & Letchworth Co., Inc., 189 Tonawanda St., Buffalo; *for mail,* 45 Courier Blvd., Kenmore.
POORMAN, Geo. E. (J'36), Weight's Engr., Curtiss Aeroplane & Motor Co., Vulcan St. & Kenmore Ave., Buffalo; *for mail,* 50 Tremaine Ave., Kenmore.
RAYMOND, Allen A. ('31), Supt., Fuel & Loco. Performance, N. Y. Cent. R. R., Rm. 1301, Cent. Terminal Bldg.
REA, John A. (J'33), Research Engr., Linde Air Products Co., 169 Chandler St.
REED, Wm. (J'36), Apprentice Engr., Worthington Pump & Mchy. Corp., Roberts Ave.; *for mail,* 1837 Seneca St.
RICE, Howard C. ('20), Pres., C. Kurtzmann & Co., 526 Niagara St.
RIESNER, Michael ('14), 235 Hartwell Rd.
ROBINSON, Horace H. (J'31), 347 Humboldt Pkwy.
SAHAROFF, Alex V. ('25), Cons. Engr., Compressor Div., Worthington Pump & Mchy. Corp., Clinton St. & Roberts Ave.
SAWDON, W. W. (J'36), Buffalo Forge Co., 125 North St., Buffalo; *for mail,* 1018 E. State St., Ithaca.
SCHUSTER, Arthur W. ('35; '35), Sales Rep., Worthington Pump & Mchy. Corp., Buffalo; *for mail,* 1383 Eggert Rd., Eggertsville.
SCHWANHAUSSER, Edwin J. ('16; '25; '35), Gen. Mgr., Buffalo Wks., Worthington Pump & Mchy. Corp., Roberts Ave. & Clinton St.
SCHWARZ, Eugene A. ('22; '28), Mgr., Geo. L. Squier Mfg. Co., 490 Broadway, Buffalo; *for mail,* 264 Washington Highway, College Hill, Snyder.
SCRANTON, Donald H. ('29), Asst. Supt., Huntley Sta., Buffalo Gen. Elec. Co., Elec. Bldg.; *for mail,* 156 Wellington Rd.
SHARP, Herbert M. ('28), Supt., Huntley Sta., Buffalo Gen. Elec. Co., Elec. Bldg.; *for mail,* 115 Tillinghast Pl.
SMITH, Harold L. ('29), Cons. Engr., 381 Ellicott Sq.
SMITH, Harry N. ('27; '35; '35), Dist. Sales Mgr., Union Collieries Co., Walbridge Bldg., Buffalo; *for mail,* 350 Brantwood Rd., Eggertsville.
SMITH, LeRoy I. (J'34), Exper. Engr., Fedders Mfg. Co., 57 Tonawanda St., Buffalo; *for mail,* Limerick.
SMITH, Wm. A. ('18; '26; '35), Mgr., Gasoline & Oil Depts., Larkin Co., Inc., 680 Seneca St., Buffalo; *for mail,* 48 Long Ave., Hamburg.
SOWERS, David W. ('15), Pres. & Treas., Sowers Mfg. Co., 1300 Niagara St.
STOCKWELL, Ray C. ('34; '35), Supvr. Opera., Buffalo Gen. Elec. Co., Genesse St.; *for mail,* 253 Crowley Ave.
STRATTON, Geo. W. (J'32), Spec. Apprentice, Motive Power Dept., N. Y. Cent. R. R., 1728 Bailey Ave.; *for mail,* 230 Highgate Ave.
STROWGER, Earl B. ('34), Hyd. Engr., Buffalo, Niagara & East. Power Corp., Elec. Bldg., Buffalo; *for mail,* 62 Stillwell Ave., Kenmore.
TERWILLIGER, Hal R. (J'31), Design Engr., Natl. Aniline & Chem. Co., Box 975.
TINKER, Townsend (J'29), *Junior Award,* '33; Ch. Engr., Ross Heater & Mfg. Co., Inc., 1407 West Ave.
TRAUDT, Wm. F. ('14; '20), Pres., & Gen. Mgr., Taber Pump Co., 291 Elm St., New York; *for mail,* 7 Argyle Park, Buffalo.
TYNG, Arthur ('13), Cons. Engr., 1515 Liberty Bank Bldg.
ULLRICH, Albert C. (J'33), 93 Red Jacket Pkwy.
VanDERVEER, T. W. ('21), Engrg. Supvr., Natl. Aniline & Chem. Co., 351 Abbott Rd.
WELLINGTON, Frederick C. (J'34), Exper. Engr., Air Conditioning, Fedders Mfg. Co., 57 Tonawanda St., Buffalo; *for mail,* W. Stockholm.
WENDEL, D. P. ('34; '35), Ch. Boiler Opera., C. R. Huntley Sta. 2, Buffalo Gen. Elec. Co., Elec. Bldg.; *for mail,* 374 Minnesota Ave.
WENDT, Edgar F. ('21), Pres. & Treas., Buffalo Forge Co., 490 Broadway.
WENTZ, Heidel H. ('26), Repair Order Supvr., Worthington Pump & Mchy. Corp.
WITTE, Felix ('21), M. E., Ch. Draftsman, Zaremba Co., 506 Crosby Bldg.; *for mail,* 335 Bedford Ave.
WOODS, Marvin Kenneth (J'36), Propeller Engr., Curtiss Aeroplane & Motor Co., Vulcan & Kenmore Ave.; *for mail,* 55 Kensington Ave.
WRIGHT, Fred'k W., Jr. (J'32), 210 Anderson Pl.
YATES, Jas. L. ('24; '33), Ch. Inspr., Worthington Pump & Mchy. Corp., Box 953.
YOUNG, Peter J., Jr. (J'34), Mech. Draftsman, Natl. Aniline & Chem. Corp., Abbott Rd.; *for mail,* 3442 Main St.

CANAJOHARIE

McBEAN, D. M. (J'24), Cons. Engr., Beech-Nut Packing Co.
SOWDEN, Park T. ('08; '15; '20), V. P., & Gen. Mgr., Arkell & Smiths; Pres., Rope Paper Sack Mfrs.

CANASTOTA, Syracuse Section

CASLER, Herman ('01; '24), M. E., 326 N. Peterboro St.
DEW, Donald H. (J'16), Pres., Charge Sales, Diemolding Corp., Rasbach St.

CATSKILL

KEABLES, Austin D. ('10; '17; '20), Engr., 164 Spring St.

CATTARAUGUS

MEROW, Edw. J. (J'33), c/o Oakes & Burger Co., Cattaraugus; *for mail,* Little Valley.

CHAMPLAIN

DAME, Emmet A. (J'33), Draftsman, Sheridan Iron Wks.; *for mail,* Champlain.

CHAPPAQUA, Metropolitan Section

COOKE, John C. (J'30), Ridge Dr.

CHESTERTOWN

STARBUCK, Robt. A. (J'33), Engr., Boiler House, Imperial Paper & Color Corp., Glens Falls; *for mail,* Chestertown.

CLAYTON

KEMP, W. V. A. ('25), Private Consultant.

COHOES, Schenectady Section

McKEE, Hugh, Jr. (J'31), 205 Congress St.

COLLEGE POINT, L. I., Metropolitan Section

ALTER, Horace J. (J'31), Design Draftsman, Edo Aircraft Corp., College Point; *for mail,* 1914 E. 27th St., Brooklyn.
BUSCH, Frank ('32; '35), Designer, Filtration Equip. Corp., 10 E. 40th St., New York; *for mail* 124-18—25th Rd., College Point.
JAKOBY, Anton (J'35), 9-35—128th St.
PAPPAS, C. Ernest (J'33), 9-34—122nd St.

CORNING, Ithaca Section

FAIRMAN, Stanley W. (J'33), Plant Engrg. Dept., Corning Glass Wks.; *for mail,* 163 E. 2nd St.
GREER, Chas. H. (J'35), Plant Engrg. Dept., Corning Glass Wks.; *for mail,* 251 Bridge St.
HORNE, John P. (J'36), 163 E. 2nd St.
IRELAND, Wm. F. A. (J'32), Foreman, Refrigerator Insulation, Corning Glass Wks.; *for mail,* 9 Sims Ave.
MORROW, Lester Wm. Wallace ('23), Gen. Mgr., Fibre Products Div., Corning Glass Works; *for mail,* 134 E. 4th St.
VAKSDAL, Alfred ('24), Plant Engr., Corning Glass Wks.; *for mail,* 55 Goff St.
WARD, Richard C. ('28; '35; '35), Engrg., Charge Constr. & Distribution, Crystal City Gas. Co., 26 E. Market St.
WEBER, W. C. ('36), Charge Mech. Devel., Corning Glass Wks.

CORONA, L. I., Metropolitan Section

LUCKERT, Chas. F., Jr. (J'29), 3517—100th St.
MARTORANO, Philip (J'33), 3317—99th St.
NULLE, J. Howard (J'36), Asst. to M. M., A. A. Johnson Co. & Necaro Corp., Inc., 111 St. & Corona Ave., Corona; *for mail,* 1185 Park Ave., New York.
PANUSKA, Frank C. ('14; '21; '26), 3346—98th St.
RUSIE, Wm. F. (J'33), 3124—106th St.

CORTLAND, Syracuse Section

ILLMER, Louis ('13), Pat. Atty., Research Engr., 111 Port Watson St.; *for mail,* 24 N. Church St.

CRESTWOOD, Metropolitan Section

LIPTAY, John M. ('29), Pres., Lab. Furniture Co., 37-18 Northern Blvd., Long Island City; *home address,* 353 Westchester Ave., Crestwood.
MOLER, Frank W., Jr. (J'34), Engr., Supervision & Design, Griscom-Russell Co., 285 Madison Ave., New York; *home address,* 43 Pennsylvania Ave., Crestwood.

CROTON, Metropolitan Section

JULSRUD, Rolf S. ('28; '32; '35), Croton Dam Rd.

DANSVILLE

GORMEL, Edmond F. (J'34), 12 Clinton St.

DELMAR, Schenectady Section

HALL, Ronald S. ('25; '35), Factory Rep., Dur[illegible] Pump Co.; *for mail,* Kenwood Ave.

DOBBS FERRY, Metropolitan Section

ROGERS, George Alexander (J'33), Ch. Engr., Cent. Htg. & Power Plant, Children's Village.
SPIRO, Walter J. ('20), Treas. & Gen. Mgr., [illegible] Spiro Mfg. Co., Dobbs Ferry; *for mail,* 2 New York Ave., White Plains.

SUTHERLAND, Kenneth W. ('19), Valuation Engr., Bartlett Hayward Div., Koppers Co., 50 Church St., New York; *for mail,* 188 Broadway, Dobbs Ferry.
SVENSON, Robt. H. ('22; '35), Maint. Engr., Anaconda Wire & Cable Co., Hastings-on-Hudson; *for mail,* 36 Bellewood Ave., Dobbs Ferry.
YOUNGSON, Alex. C. ('22; '30), 27 Seneca St.

DONGAN HILLS, S. I., Metropolitan Section

SEAVER, Cletus A. (J'28), Asst. Engr., Office of Richmond Borough Pres., Borough Hall, St. George, S. I.; *for mail,* 30 Cromwell Ave., Dongan Hills.

DOUGLASTON, L. I., Metropolitan Section

EWRY, Ray C. ('28), M. E., Bd. of Water Supply, 346 Broadway, New York; *for mail,* 343 Ridge Rd., Douglaston.

EAST ROCHESTER, Rochester Section

LINDSEY, Jos. T. (A'26), Gen. Supt. Case Shop, Foster-Armstrong Co., E. Rochester; *for mail,* 65 Queen St., Rochester.

EAST SYRACUSE

MOEN, L. W. ('19; '35), Charge Mch. Shop, M. L. Oberdorfer Brass Co., Thompson Rd., E. Syracuse; *for mail,* 123 Lynwood Ave., Syracuse.

EASTVIEW, Metropolitan Section

VEHSLAGE, Harold E. ('12; '19; '20), Exec. Secy., Westchester County Dept. of Pub. Wks., Eastview; *for mail,* 26 Sage Terrace, Scarsdale.

ELLENVILLE

AHRENS, Geo. C. (J'32), 20 Mill St.

ELMHURST, L. I., Metropolitan Section

ADAMS, John E. ('27; '35), 8408—63d Ave.
BAECHER, Bernard Jos. (J'35), Natl. Bur. of Stands., Washington, D. C.; *for mail,* 90-49—52nd Ave., Elmhurst, L. I., N. Y.
BOWMAN, Richard G. (J'32), Engr., Stress Analysis, Seversky Aircraft Co., Farmingdale, L. I.; *for mail,* 92-05 Whitney Ave., Elmhurst.
COYNE, Thos. D. (J'36), 54-09—94th St.
GROSCHOFF, Ernst H. (J'33), 44-18 Ketcham St.
HARMAN, Francis F. (J'28), 47-06—88th St.
KERN, Jos. F., Jr. (J'32), Asst. Editor, Heating & Ventilating, 148 Lafayette St., New York; *for mail,* 42-15—79th St., Elmhurst.
KUKOWITZ, Louis J. (J'28), 79-25 Ankener St.
LOCKWENZ, Adolph C. ('23; '35), Mech. Designer, Bd. of Transportation, City of New York, 250 Hudson St., New York; *for mail,* 42-49 Forley St., Elmhurst.
LUCKNER, Leo B. (J'36), Mech. Draftsman, Bell Tel. Labs., Inc., 463 West St., New York; *for mail,* 8713—55th Ave., Elmhurst.
MIESEL, Christian (J'36), Draftsman, Sherb Wood Co., 342 Madison Ave., New York; *for mail,* 53-06 Haspel St., Elmhurst.

ELMIRA, Ithaca Section

EVANS, Leigh R. ('18), V. P., Morrison Mch. Products, Inc.; *for mail,* 114 Country Club Dr.
KENNEDY, John C. ('30), V. P., Secy., Wks. Mgr., Charge Mfg., Kennedy Valve Mfg. Co., E. Water St.
KENNEDY, Matthew E. ('06; '30), Pres. & Treas., Kennedy Valve Mfg. Co., 1050 E. Water St.
KINSMAN, Richard E. ('14; '25), 3 Strathmont Park.
KURZINA, S. B., Jr. (J'28), Y. M. C. A.
LINKE, F. J. ('27), Auto. Equip., Repairs, Service, 401 Baldwin St.; *for mail,* 300 Lormore St.
SCHWENNESEN, H. A. ('21), Estimating Engr., Elmira Light, Heat & Power Corp., 201-203 State St.; *for mail,* 908 Bridgman St.
SROGI, L. (J'36), Design & Devel. Wk., Eclipse Mch. Co.
SZEKELY, Otto E. ('27), Pres., Szekely Engrg. Corp., 501 E. Clinton St.
WHITNEY, M. P. ('30), Ch. Engr., Eclipse Mch. Co.; *for mail,* 966 W. Church St.

ELMSFORD, Metropolitan Section

JENSEN, David A. ('24; '35), Designer, P. O. Box 342.

ENDICOTT, Ithaca Section

ANDERSON, Carl O. ('21; '27; '35), Designer, Internatl. Business Mchs. Corp., North St.; *for mail,* 415½ Adams Ave.
CAMPBELL, Jas. S., Jr. (J'34), Student Engr., Internatl. Business Mchs. Corp., Endicott; *for mail,* 6 Elk St., Cooperstown.
HAYNES, Stephen S. (J'33), Internatl. Business Mchs. Corp., Endicott; *for mail,* 26 Lewis St., Johnson City.
HENDRICH, H. Alfred (J'30), Designing Engr., Internatl. Business Mchs. Corp., North St.; *for mail,* 102 Grant Ave.
MEYER, Alvin D. (J'34), Student Engr., Internatl. Business Mchs. Corp.; *for mail,* P. O. Box 243.
SCHLOBACH, Geo. F. (J'35), Student Engr., Internatl. Business Mchs. Corp.; *for mail,* 1905 Monroe St.
STEFANO, Nicholas (J'36), Student Engr., Internatl. Business Mchs. Corp.; *for mail,* 1905 Monroe St.
VON PEIN, Edw. J. ('13), Devel. Engr., Internatl. Business Mchs. Corp.

ESSEX

STAFFORD, Paris H. (J'36), Engr. Pump Dept., Am. Engrg. Co., Kensington Sta., Philadelphia, Pa.; *for mail,* R. F. D. 1, Essex, N. Y.

FAIRPORT, Rochester Section

BROWN, Robt. T. (J'35), Research & Prod. Engr., Am. Can Co., Parce Ave.

FARMINGDALE, L. I., Metropolitan Section

GARGES, John Paul Donald (J'32), Aero. Engr., Design, Grumman Aircraft Engrg. Corp., Conklin St., Farmingdale; *for mail,* 10 Huntington Rd., Garden City, L. I.
PROBST, Jos. (J'33), Inspr., Grumman Aircraft Engrg. Corp., Farmingdale; *for mail,* 8624—125th St., Richmond Hill, L. I.
STERN, Jos. H. (J'17), Project Engr., Ranger Engrg. Corp.

FAR ROCKAWAY, L. I., Metropolitan Section

HOWLAND, Lewis A. ('10), V. P., Gen. Mgr., Queens Borough Gas & Elec. Co.

FISHKILL, Metropolitan Section

GLEIM, Geo. W. (J'35), M. E., Research, Tex. Co., Glenham; *for mail,* Box 616, Fishkill.

FLORAL PARK, L. I., Metropolitan Section

CASSIDY, Patrick F. ('29), Sales Engr., W. B. McVicker, 295 Douglas St.; *for mail,* 44 Geranium Ave.

FLUSHING, L. I., Metropolitan Section

APT, Sanford R. ('26), M. E., Charge Heating, Ventilating, Air Conditioning, New York World's Fair 1939, Inc., 350—5th Ave., New York; *for mail,* Apt. 2C, 3620—168th St., Flushing.
BURDICK, Theo. A. ('18; '25), 3036—152nd St.
GERSBACH, Herbert A. (J'32), Engr., Percy Mfg. Co., Inc., 101 Park Ave., New York; *for mail,* 5530—153rd St.
GOODWIN, Thos. L., Jr. (J'22), Supt., Charge Distribution, Consltd. Edison Co. of N. Y., Inc., 136-21 Roosevelt Ave.
HARRIS, Horace W. (J'30), Ch. Engr., Bd. of Education, Pub. Sch. 20, Flushing; *for mail,* 64-65—83rd St., Forest Hills W., L. I.
HAVENS, Kenneth B. (J'35), 43-71—164th St.
ISENBERG, Martens H. ('18; '21; '35), V. P., Charge Mfr., Combustion Engrg. Co., Inc., 200 Madison Ave., New York; *for mail,* 3344—161st St., Flushing.
KEENER, H. Jas. (J'35), Engr., Anchor Cap & Closure Corp., 22 Queens St., Long Island City; *for mail,* 142-12 Poplar Ave., Flushing.
KENDING, Ernest K. ('35), 141 Broadway, New York; *for mail,* Hotel Sanford, Flushing.
KEPPEL, Howard B., Jr. ('29; '35), Cons. Engr., 35-20 155th St.
KIERNAN, Francis R. (J'35), Time Study Engr., Am. Chicle Co., 30-30 Thompson Ave., Long Island City; *for mail,* 45-18—149th St., Flushing.
PETERSON, Oscar F. ('22; '35), Asst. Supt., New Amsterdam Gas Co., 7-18—37th Ave., Long Island City; *for mail,* 42-36—191st St., Flushing.
REYNELL, Carleton ('20; '23), Gen. Pur. Agt., Worthington Pump & Mchy. Corp., Harrison, N. J.; *home address,* 42-66 Phlox Pl., Flushing, L. I., N. Y.
SABIN, A. H. ('96), Cons. Chemist, Natl. Lead Co., 111 Broadway, New York; *for mail,* 150-03 Sanford Ave., Flushing.
SCHMID, Albert H. (J'35), 40-11—150th St.
SPEAR, Maynard H. ('15), Mgr., Gas Dept., Flushing Dist., Consltd. Edison Co. of N. Y., Inc., 136-21 Roosevelt Ave.
THOMSON, Saml. G. ('16), Cons. Engr., 3702—147th St.
WINGE, Otto C. ('16; '21), Tech. Engr. Asst., New York & Queens Elec. Light & Power Co., 40-22 Lawrence St., Flushing, L. I., N. Y.; *for mail,* 64 Knox Ave., Grantwood, N. J.
WORTHLEY, Herbert S., Jr. (J'35), Asst. Engrg. Supvr., Wks. Progress Admin., City of New York, 70 Columbus Ave., New York; *for mail,* 35-54—169th St., Flushing.

FOREST HILLS, L. I., Metropolitan Section

BAUMAN, Harold A. (J'25), N. Y. Edison Co., Inc., New York; *for mail,* Apt. 5E, 73-37 Austin St., Forest Hills.
BLACK, Donald R. ('20; '35), Struc. Engr., Merritt-Chapman & Scott Corp., 17 Battery Pl., New York; *for mail,* 6824 Dartmouth St., Forest Hills.
BOYCE, Geo. Phillips (J'35), 62 Greenway Terrace.
EDER, Jas. P. (J'34), Sales Engr., Am. Radiator Co., 40 W. 40th St., New York; *for mail,* 64 Groton St., Forest Hills.
JAHN, Edgar Allen (J'35), 70-41 Loubet St.
MACDONALD, Edw. T. ('27; '35), M. E., Charge Opera., Maint. & Pur., St. Marys Hospital, Buffalo & St. Marks Aves., Brooklyn; *home address,* 71-50 Manse St., Forest Hills.
NEWPORT, Victor G. (J'23), Estimator, Babcock & Wilcox Co., 19 Rector St., New York; *for mail,* 85-80—67th Ave., Forest Hills.
PUTNAM, Stuart T. (J'36), 78-11 Kew Forest Lane.
TINGHIR, Vahe (J'22), Engrg. Consultant, State Dept., Washington, D. C.; *for mail,* 109-20 Queens Blvd., Forest Hills, L. I., N. Y.
VIERGUTZ, Chas. F., Jr. (J'34), Spec. Sales Agt., Hobart Mfg. Co., 45 E. 27th St., New York; *for mail,* 8540—67th Rd., Forest Hills.

FREEPORT, L. I., Metropolitan Section

FUCHS, Chas. A. ('31; '35), Freeport Machine Wks., Sunrise Highway & Columbus Ave., Freeport; *for mail,* Barnum Ave., Plainview, Hicksville, L. I.
MILLER, W. B. ('23; '33; '35), Sales Wks., Exec., A. Siegel & Co.; *for mail,* 190 S. Long Beach Ave.

FREWSBURG

HILLER, Maurice L. (J'32), 49 Pearl St.

FULTON, Syracuse Section

HASKELL, J. Dennis ('21; '31), Secy. & Engr., Dilts Mch. Wks., Inc.
PAUGH, Chas. T. ('18; '20; '25), Ch. Engr., Charge Plant, Peter Cailler Kohler Swiss Chocolates Co.; *for mail,* 353 Division St.
WILBER, Abert (J'31), R. F. D. 7.
WILBER, Walter B. (J'27), 7 N. 6th St.

GARDEN CITY, L. I., Metropolitan Section

BERRY, D. W. (J'36), 123 Tullamore Rd.
BISHOP, Geo. C. (J'35), 114—9th St.
BLIZARD, John R. (J'35), 7 Cedar Pl.
EVANS, Norman A. (J'30), East. Sales Rep., Pressed Steel Tank Co., 52 Vanderbilt Ave., New York; *home address,* 22 Roosevelt St., Garden City.
HAUSER, Geo. H. ('18; '31), 29 Hilton Ave.
MEJO, Ernest O. (J'30), M. E., Supt. Bldgs. & Grounds, Bd. of Education.
UNDERWOOD, Enoch W. ('19; '35), Gen. Mgr., Charge Opera., Arbuckle Bros., Foot of Jay St., Brooklyn; *home address,* 58—3rd St., Garden City.
WYLD, Jas. H. (J'36), 72—2nd St.

GENEVA, Ithaca Section

HERENDEEN, Fred'k W. ('20), Secy., Inst. of Boiler & Radiator Mfrs., 29 Seneca St.
PALMER, Henry O. ('20), Pres., Empire Gas & Elec. Co., 103 Castle St.

GLEN COVE, L. I., Metropolitan Section

CHURCHILL, Alan W. (J'32), Box 63.

GLENDALE, L. I., Metropolitan Section

PETERSEN, John H. (J'34), 71-06—69th Pl.
STEFFAN, Christian H. ('27; '36), Asst. Supt., Charge Shift, Arbuckle Bros., Pearl & John Sts., Brooklyn; *for mail,* 80-10—78th Ave., Glendale.

GLENS FALLS

AVERY, True M. ('31), Mgr. of Factories, Union Bag & Paper Corp., Woolworth Bldg., New York; *for mail,* 29 Lincoln Ave., Glens Falls.
HARVEY, Kenneth Howard (J'35), Safety Engr., Finch, Pruyn & Co., Inc., 1 Glen St.; *for mail,* 16 Gage Ave.
HOOPES, Maurice ('01), Pres., Finch, Pruyn & Co., Inc., Box 350.
JAMISON, Geo. S. ('18; '34), Secy., Charge Spec. Risk, Glens Falls Ins. Co., 191 Glen St.
LYALL, John D. (J'31), A. E. Broughton & Co.
SMITH, Edwin Geo. (J'32), Dept. Foreman, Wallpaper Div., Imperial Paper & Color Corp.; *for mail,* Box 98.
WIEBER, Geo. A. ('15; '20; '35), Div. Mgr., N. Y. Power & Light Corp.; *for mail,* 11 Coolidge Ave.

GLENWOOD LANDING, L. I., Metropolitan Section

KELLY, John T. (J'30), Inspr., Power Plant Constr. Wk., E. L. Phillips & Co., Glenwood Landing; *for mail*, 222 Harrison Ave., Mineola, L. I.

GLOVERSVILLE, Schenectady Section

FETTERS, Geo. H. (J'36), Ch. Engr., Power Plant, Surpass Leather Co., North & Willow Sts.; *for mail*, 9 Highland Terrace.
WOOD, Richard L. (J'33), Curtin & Hebert Co., 9 Forest St.; *for mail*, 32 Highland Terrace.

GRANT CITY, S. I., Metropolitan Section

BRANDES, Luther C. ('31; '35), 180 Midland Ave.

GREAT KILLS, S. I., Metropolitan Section

HURREY, Ross C. (J'27), 235 Broadway.

GREAT NECK, L. I., Metropolitan Section

HANSEN, Edw. H. ('36), 250 Park Ave., New York; *for mail*, 1—4th Rd., Great Neck.
HATZFELD, Geo., Jr. (J'34), Steam Tester, Testing Bur., Williamsburgh Power Plant Corp., 385 Flatbush Ave. Ext., Brooklyn; *for mail*, 176 Overlook Ave., Great Neck.
MESSNER, Manfred ('13; '17; '31), Ch. Engr., Bing & Bing, Inc., 119 W. 40th St., New York; *for mail*, 2 N. Clover Dr., Great Neck, L. I.
NICHOLS, Wallace H. (J'29), Commercial Rep., N. Y. Tel. Co., Shoreward Dr., Great Neck; *for mail*, 37 Bar Beach Rd., Port Washington, L. I.
SPERRY, Samuel E., Jr. ('17; '24; '35), Engrg. Draftsman, Port of N. Y. Authority, Weehawken, N. J.; *for mail*, 258-14 Kensington Pl., Great Neck, L. I., N. Y.
TUTTLE, Irving Edwin ('09; '15; '26), Supvr. Engr., Marc Eidlitz & Son, Inc., 100 E. 42nd St., New York; *for mail*, 4 Lodge Rd., Great Neck.

GROTON, Syracuse Section

AVERY, Henry Lewis (J'34), 310 Cortland St.

HAMBURG, Buffalo Section

BAILEY, Jas. ('19; '33), V. P., Charge Research, Bailey & Sharp Co., Inc., Pleasant Ave.; *for mail*, 79 Central Ave.
BRIDGMAN, Robt. R. ('25; '34; '35). Ch. of Time Study, Ford Motor Co., Fuhrman Dr., Buffalo; *for mail*, 190 S. Creek Rd., Hamburg.

HARMON-ON-HUDSON, Metropolitan Section

HULBERT, Carlton S. (J'34), Box 377.

HARTSDALE, Metropolitan Section

MORRIS, John A. (J'33), 53 Holmes Ave., Hartsdale Manor.
NORVIG, Johan ('13), Supt., Lone Star Cement Corp., Hudson; *home address*, 25 Clubway, Hartsdale.
WILLIAMS, Frederic S. ('25; '35), Designing Engr., Am. Safety Razor Corp., 315 Jay St., Brooklyn; *for mail*, 5 Holland Ave., Hartsdale.

HASTINGS-ON-HUDSON, Metropolitan Section

BRYANS, Wm. R. ('19), Prof., Engrg. Mechanics, Asst. Dean, College of Engrg., N. Y. Univ., University Heights, New York; *home address*, Hastings-on-Hudson.
HEMSTREET, Geo. P. (06), V. P., Engrg. & Sales, Hastings Pavement Co.; *for mail*, 50 Circle Dr.
KOCH, Bruno F. ('21; '26), Engr., Power Plant Design, Anaconda Copper Min. Co., c/o Anaconda Wire & Cable Co.
MacLEOD, Lester R. ('30), Mech. Designer, Anaconda Copper Min. Co., Hastings-on-Hudson; *for mail*, 100 Ridge Rd., Ardsley.
TWADDELL, Russell W. (J'35), M. E. Research, Anaconda Wire & Cable Co.; *for mail*, 33 Whitman St.

HEMPSTEAD, L. I., Metropolitan Section

SPAHN, Chas. F. (J'33), R. F. D. 3, 20 May St.

HEWLETT, L. I., Metropolitan Section

DILG, Walter C. (J'36), Drafting, Waugh Equip. Co., 420 Lexington Ave., New York; *for mail*, 1160 E. Broadway, Hewlett.

HOLLIS, L. I., Metropolitan Section

DVORAK, Clfford J. (J'35), 19403—104th Ave.
HANAUER, Elbert A. (J'32), 92-16—195th Pl.
HECK, John Wilson (J'36), 19615—100th Ave.
MUNSON, Stanley ('11; '25), Engr., Design, Colgate-Palmolive-Peet Co., 105 Hudson St., Jersey City, N. J.; *for mail*, 89-11—198th St., Hollis, L. I., N. Y.
RANTSCH, Edw. J. ('28), Design Engr., John Royle & Sons, Essex & Straight Sts., Paterson, N. J.; *for mail*, 10445—197th St., Hollis, L. I., N. Y.
RIVE, Lewis Hooper (J'34), 196-07 Hollis Ave.
SCHURICHT, Carl O., Jr. (J'36), 192-12—109th Rd.

HOMER, Syracuse Section

BURDEN, Howard W. (J'25), Salesman, Rock Wool Insulation Corp., Westmoreland Ave., White Plains; *for mail*, 3 Copeland Ave., Homer.

HOWES CAVE, Schenectady Section

CAMPBELL, John Woodward ('31), Supt., N. Am. Cement Corp.; *for mail*, P. O. Box 75.

HUDSON FALLS

MARSHALL, Arnold R. (J'36), Asst. Engr., Maint. & Design, Union Bag & Paper Corp.; *for mail*, 10 Main St.
PARKS, Mayo B. (J'36), Mgr. Gas Sta., Ezro R. Dickinson, 92 Oak St.

HUNTINGTON STATION, L. I., Metropolitan Section

FIGELMAN, Benj. (J'34), 87 Olive St.
RONKANEN, Vaine A. ('24; '31; '35), 21 Ritter Ave.

IRVINGTON, Metropolitan Section

HEYL, Edw. B. (J'33), 25 Sunnyside Pk., Irvington-on-Hudson.

ISLIP, L. I., Metropolitan Section

WILLIAMSON, Christian T. (J'29), 3 Athasca Rd.

ITHACA, Ithaca Section

ALBERT, Calvin D. ('11), Prof. Mch. Design, Cornell Univ.; *for mail*, 23 East Ave.
ANDREWS, Robt. Mills (J'35), Serv. Man, Internatl. Business Mchs. Co.; *for mail*, 421 N. Geneva St.
ARMSTRONG, Cecil W. (J'35), Instr., Mechanics of Engrg., Sibley Sch. of Mech. Engrg., Cornell Univ.
BARNARD, Wm. N. ('00; '05), Prof. Heat-Power Engrg., Sibley Sch. of Mech. Engrg., Cornell Univ.; *for mail*, 4 South Ave.
BARR, John H., Sr. ('89), Manager, '15-'18; 505 E. Seneca St.
BRAND, Walter N. ('12), V. P., Charge Factory, Allen-Wales Adding Mch. Co.; *for mail*, 416 Cayuga Heights Rd.
CARMICHAEL, Colin ('30; '35; '35), Asst. Prof. Mch. Design, College of Engrg., Cornell Univ.; *for mail*, 128 Blair St.
CARPENTER, Geo. D. ('19), Supt. Water Dept., City Hall; *for mail*, 903 E. State St.
CORNELL, W. Rodney ('25), Prof. M. E., Cornell Univ.; *for mail*, 507 Hanshaw Rd.
DIEDERICHS, Herman ('04; '13), *Melville Medallist*, '30; Dean, College of Engrg. & Dir., Sibley Sch. of Mech. Engrg., Cornell Univ.
ELLENWOOD, Frank O. ('13), Prof. Heat-Power Engrg., Cornell Univ.; *for mail*, 111 Harvard Pl.
ERDMAN, Fred'k S. ('28; '36), Graduate Student, Cornell Univ., Graduate Sch.; *for mail*, 122 College Ave.
ERNSBERGER, Millard C. ('10), Prof. M. E. Emeritus, Cornell Univ.; *for mail*, 107 Cook St.
FRIED, Jerome A. ('14; '25), Owner, Ithaca Scien. Instrument Co., P. O. Box 555.
GAGE, Victor R. ('36), Prof., Cornell Univ.
GARNER, Enoch F. ('19), Asst. Prof., Cornell Univ.; *for mail*, 305 Elmwood Ave.
GARRETT, Seymour S. ('16), 115 Oak Hill Rd.
HOLLISTER, S. C. ('34), Assoc. Dean, College of Engrg. & Dir., Sch. of Civ. Engrg., Cornell Univ.
HOOK, Warren H. ('21), Asst. Prof., Heat-Power Engrg., Cornell Univ.; *for mail*, 105 Harvard Pl.
KEITH, Rafael Wm. (J'30), Keith Independent Research Serv., 210 College Ave.
KIMBALL, Dexter S. ('00; F'36), Manager, '19-'21; President, '22; *Worcester Reed Warner Medallist*, '33; Dean Emeritus, College of Engrg., Cornell Univ.; *for mail*, 5 Central Ave.
LINCOLN, Paul M. ('07), Dir., Sch. of Elec. Engrg., College of Engrg., Cornell Univ.
LOBERG, Harry J. (J'30), 116 Osmun Pl.
LYNAH, Jas. ('22), Belleayre Apts.
MORSE, Robt. V. ('22), Pres., Bliss-Morse Research Corp., 614 Chrysler Bldg., New York; *home address*, 106 Overlook Rd., Ithaca.
OLEKSIW, Jerome (J'31), Research Assoc., Cornell Univ., Ithaca, N. Y.; *for mail*, 303 N. Shamokin St., Shamokin, Pa.
PERKINS, Harold C. ('34), Asst. Prof. M. E., Cornell Univ.
PERRY, David B. ('26), Pres., Morse Chain Co.
RANDOLPH, Frank H. ('22; '32), Prof. Hotel Engrg., Cornell University, Box 55, Roberts Hall.
SAWDON, Will M. ('10), Prof., Exper. Engrg., Cornell Univ.
SCHICKEL, Norbert H. ('21), 305 Cornell St.
SMITH, Albert W. ('80; '92), Dean Emeritus, Sibley College, Cornell Univ.; *for mail*, 13 East Ave.
SWITZER, Fred'k G. ('27), Prof. Hyd. Engrg., Cons. Engr., College of Engrg., Cornell Univ.
UPTON, G. B. ('16), Prof. Automotive Engrg., Cornell Univ.
VAIL, Carl W. ('19; '24; '35), Asst. Supt. & Plant Engr., Morse Chain Co., P. O. Box 98; *for mail*, 207 Ithaca Rd.
WELANETZ, Ludolf F. (J'36), Instr., Engrg. Mechanics, Sibley Sch. of Mech. Engrg. Cornell Univ.; *for mail*, 1015 E. State St.
WISSEN, Geo. G. (J'30), Constr. Supvr., U. S. Dept. of Interior, Natl. Pk. Serv., S. P. 56 La Salle Sta., Niagara Falls; *for mail*, 506 S. Cayuga St., Ithaca.

JACKSON HEIGHTS, L. I., Metropolitan Section

BONNER, Col. Jos. C. ('31), Life Member; Pres., Bonner Railwagon System, Inc., Jackson Heights, L. I.; *for mail*, Hotel Victoria, 7th Ave. at 51st St., New York.
COMSTOCK, Chas. Worthington ('08), Apt. 5K, 3527—81st St.
FOWLER, Edw. L. (J'30), Designer, Anchor Cap & Closure Corp., 22 Queens St., Long Island City; *for mail*, 32-40—93rd St., Jackson Heights.
HAYES, Wm. T. ('23), 3705—79th St.
MADER, Chas. Kenneth (J'33), Estimator, M. W. Kellogg Co., 225 Broadway, New York; *for mail*, 37-52—80th St., Jackson Heights.
MERRILL, Josiah L. ('04; '20), 34-15—94th St.
MOORE, Thos. J. (J'36), Inspr., Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn; *for mail*, 3120—93rd St., Jackson Heights.
PANGBORN, Robt. G. (J'20), 7035 Broadway.
RICKCORD, R. V. ('13; '16; '35), 3447—87th St.
ROLAND, P. W. ('16; '27; '35), 3320—83rd St.
SHERMAN, Walter P. ('13), 3721—79th St.
SIMPSON, Arthur M. ('18; '35), 37-34—85th St.
VAN DOREN, W. D. ('21), M. E., Charge Design, Barrett Co., 40 Rector St., New York; *for mail*, 3720—84th St., Jackson Heights.
VINCZE, Andrew ('30; '35), Engr. of Construction, Dept. of Health; *for mail*, 9513 No. Blvd.
WINKLER, Leopold (J'32), 3131—94th St.

JAMAICA, L. I., Metropolitan Section

BURKE, Walter A. (J'32), Engr., Jamaica Swimming Pool, Jerome & Van Wyck Aves., Jamaica; *for mail*, 7420—88th Ave., Woodhaven, L. I.
CAHILL, Daniel T. (J'35), 12 Lloyd Rd.
COTTON, H. W. ('28), 161-06 Grand Central Parkway.
GOLDREYER, Lawrence L. (J'36), 8319—161st St.
KIRBY, John F., Jr. (J'33), 137-28—97th Ave.
KOCH, Geo. W. ('27), Chem. Engr. & Inspr. Combustibles, N. Y. Fire Dept., Rm. 1103, Municipal Bldg., Brooklyn; *for mail*, 8645—139th St., Jamaica.
LEASENFELD, Chas. (J'36), 170-26 Henley Rd.
NICKERSON, Alvano T. ('01), 144-65—87th Ave
SEFCSIK, Louis J. (J'34), 166-16—88th Ave.
SPOERR, Frank F. (J'32), 140-19 Queens Blvd.

JAMESTOWN

APPLEYARD, John S. (J'33), Draftsman, Marlin Rockwell Corp., 402 Chandler St.; *for mail* 334 Crossman St.
CONTERMAN, Fred A. ('27; '35), Ch. Engr. Blackstone Mfg. Co. (Div. of Jamestown Meta Equip. Co.), Allen St. Ext.; *for mail*, 13 Buffalo St.
CUMMINGS, Lloyd A. ('27), Ch. Engr., Marlin Rockwell Corp.
SCHOBECK, Arthur E. ('30), Pres. & Gen. Mgr. Jamestown Malleable Iron Corp.; *for mail*, 12 Maple St.
WALTERS, John C. (J'33), Cost Engr., Blackston Mfg. Co. (Div. of Jamestown Metal Equi Co.), Blackstone Ave.; *for mail*, 136 Maple S
WIESNER, Maurice W. ('19; '26), Gen. Supt Charge Prod. & Engrg., Dahlstrom Metalli Door Co., Buffalo St.

JOHNSON CITY, Ithaca Section

BROWNE, J. Thomas (J'29), 49 Cherry St.
HENRIKSON, Wm. (J'36), Test Engr., Ag Ansco Corp.; *for mail*, 20 Baldwin St.
WARSHAW, Sidney G. (J'29), Detailer, Agfa Ans Corp., Binghamton; *for mail*, 20 Baldwin St Johnson City.

JOHNSTOWN, Schenectady Section

BROWER, John D. (J'31), 8 W. Fulton St.

KENDALL, Rochester Section

STANGLAND, B. F. ('89; '92), M. E., Retired.

KENMORE, Buffalo Section

LINDSTROM, Gustaf T. ('36), Engr., Mech. Design, Rayon Div., E. I. du Pont de Nemours & Co., Sta. B, Buffalo; *for mail,* 494 Woodland Dr., Kenmore.

SCHULTZ, Herbert L. ('25; '30), Supt. Maint., Carborundum Co., Niagara Falls; *for mail,* 278 Paramount Pkwy., Kenmore.

WILSON, Jas. Arthur ('18; '23), 109 Westgate Rd.

KEW GARDENS, L. I., Metropolitan Section

BURNS, Wm. J. (J'30), 21 Grenfell Ave.

JOHNSON, Theo. S. (J'28), Automotive Engr., Gen. Lab., Socony-Vacuum Oil Co., Inc., 412 Greenpoint Ave., Brooklyn; *for mail,* 8364 Talbot St., Kew Gardens.

MARKSON, Alfred A. (J'25), Asst. Research Engr., N. Y. Steam Corp., 130 E. 15th St., New York; *home address,* 8216 Austin St., Kew Gardens.

KINGS PARK, L. I., Metropolitan Section

LANGHAM, Henry T. (J'28), Box 485.

STEPHENSEN, Frederik (J'35), Box 203.

KINGSTON

BURGER, Geo. E. ('24; '33), Supt., Burger Bluestone Co., P. O. Box 781.

LACKAWANNA, Buffalo Section

BARR, Henry R. (J'36), Looper, Mech. Dept., Bethlehem Steel Co.; *for mail,* 87 Dorrance Ave.

BUSTER, Robt. (J'36), Student Engr., Bethlehem Steel Co.; *for mail,* 10 Melroy St.

ECKHARDT, Floyd Smith (J'36), Ch. Draftsman, Bethlehem Steel Co., Lackawanna; *for mail,* 45 Lake St., S. Hamburg.

LANCASTER, Buffalo Section

BARGER, Lorin W. ('13), Wks. Engr., Symington-Gould Corp., Rochester; also Gould Coupler Corp., Depew; *for mail,* 30 Cayuga St., Lancaster.

LARCHMONT, Metropolitan Section

CORNELL, Edw. S., Jr. ('32), V. P., Devel. Engr., Am. Radiator Co., 40 W. 40th St., New York; *for mail,* 17 Campbell Lane, Larchmont.

MEYER, Erwin C. ('11; '15; '35), Secy. & Supt., Pure Food Factory "Hansa," 430 Mamaroneck Ave., Mamaroneck; *for mail,* 44 Woodbine Ave., Larchmont.

VESSELS, F. Stephen (J'31), 44 Maykew Ave.

WOODRUFF, H. S. ('36), 18 Wildwood Circle.

LAURELTON, L. I., Metropolitan Section

PARKER, Harry M. ('30; '35), Oper. Engr., Mech. & Indus., Hopeman Bros., 19 E. 47th St., New York; *home address,* 135-33—234th Pl., Laurelton, L. I., N. Y.; *for mail,* Wayne Mfg. Co., Waynesboro, Va.

LE ROY, Rochester Section

MITCHELL, Wm. A. ('25; '35), M. E., 10 Church St.

LITTLE FALLS, Utica Section

LUNDSTROM, Carl B. ('25; '34; '35), Engr., Charge Maint. & Prod., C. J. Lundstrom Mfg. Co.

SNYDER, Harry Wm. (J'32), Asst. Factory Mgr., H. P. Snyder Mfg. Co., Inc.

WYMAN, Ellsworth (J'30), Research Dept., Cherry-Burrell Corp., Albany St.; *for mail,* 56 W. Monroe St.

LIVERPOOL, Syracuse Section

EAU, Bernard Harold (J'35), 209—6th St.

LOCKPORT, Buffalo Section

BRYANT, Robt. E. (J'18), Pres., Lockport Fittings Co., Inc., 71 Gooding St.

MUDSHALL, Wm. H. (J'36), Y. M. C. A.

LODI, Ithaca Section

TOWNSEND, Lewis M. (J'34).

LONG BEACH, L. I., Metropolitan Section

ANDERSON, Arthur Walter ('32; '35), Engr., Charge Maint., Lido Club Hotel, Inc.; *for mail,* 760 Lincoln Blvd.

LENZ, Walter J. ('35), Point Lookout.

LONG ISLAND CITY, Metropolitan Section

ALIMOFF, Walter ('29; '35), Aeroplane Designer, Merrill Aircraft Co., Long Island City; *for mail,* Apt. 6C, 3675 Broadway, New York.

BARBOLINI, Guido (J'35), Engr., Richmond Screw Anchor Co., Inc., Bush St., Brooklyn; *for mail,* 33-75—10th St., Long Island City.

BILHUBER, Paul H. ('22), Asst. Factory Mgr. & Engr. in Charge Design & Research, Steinway & Sons, Ditmars Blvd. & 45th St., Long Island City; *for mail,* 14 Richmond Rd., Douglaston, L. I.

BRETZFELDER, Morrie ('21; '35), Pres., Gen. Conveyor Co., Inc., 22nd St. & 39th Ave.

CASSEBEER, Theo. (A'26), Factory Mgr., Steinway & Sons, Ditmars Blvd. & Titus St.

CLANCY, Jas. R. ('24; '32; '35), Commercial Engr., N. Y. & Queens Elec. Light & Power Co., 28-19 Bridge Plaza, N., Long Island City; *for mail,* 147-37—9th Ave., Whitestone, L. I.

COLSON, Erick G. ('20; '35), Factory Supt., Ford Instrument Co., Inc., Rawson St. & Nelson Ave.

CROSBY, John (J'35), 4319—41st St.

CROWLEY, John M. (J'34), Test Engr., Ford Instrument Co., Inc., Rawson St. & Nelson Ave.

CROWTHER, Geo. Alfred (J'31), Design Engr., Ford Instrument Co., Inc., Rawson St. & Nelson Ave., Long Island City; *for mail,* 127 Chase Rd., Manhasset, L. I.

DEAN, Harold C. ('27), V. P., N. Y. & Queens Elec. Light & Power Co., 28-19 Bridge Plaza.

DeKEYSER, Jacques F. ('29), Factory Mgr., Westinghouse X-Ray Co., Inc., 21-16—43rd Ave., Long Island City; *for mail,* 37-53—78th St., Jackson Heights, L. I.

EMERSON, John Paul (J'35), Inspr., Waldes Koh-i-noor, Inc., 47-52—27th St., Long Island City, N. Y.; *for mail,* Box 83, Demarest, N. J.

FINK, E. C. ('13; '14), V. P., Internatl. Motor Co., 34th St. & 48th Ave., Long Island City; *for mail,* 251 W. 89th St., New York.

FRIEDMAN, Gerald ('34; '35), Ch. Engr., Public Serv. Heat & Power Co., Inc., 41-14—27th St.

GARRETT, Elmer E., Jr. (J'29), Design Engr., Ford Instrument Co., Inc., Rawson St. & Nelson Ave., Long Island City; *for mail,* 92-43—240th St., Bellerose, L. I.

GLEESON, John M. ('19; '26; '35), Sales Promotion Engr., Westinghouse X-Ray Co., Inc., Long Island City; *for mail,* 5215 Redfield St., Douglaston, L. I.

GUZZETTI, Alfred John (J'32), Lab. Asst., Bloomingdale Bros. Warehouse, Long Island City, N. Y.; *for mail,* 149 Chestnut St., Leonia, N. J.

HAMMETT, Philip M. ('10), 3919—49th St.

HANNANT, T. N. (J'31), Jr. Engr., Engrg. Lab., Ford Instrument Co., Rawson St. & Nelson Ave.

HAYNES, Wm. E. ('23; '26; '35), Instr. Mch. Shop Practice, Jamaica Vocational High Sch., 92-23—170th St., Jamaica, L. I.; *for mail,* 42-10—23rd Ave., Long Island City.

HAZARD, Chas. Sprague ('34), Ch. Engr., Charge Design, Neptune Meter Company, 192 Jackson Ave.

HESS, Jacob (J'34), Charge Design & Maint., Comolite Corp., 42-61—24th St.

HILLE, Edw. (J'36,) Engr., Sales Dept., Timken Silent Automatic Co. (Div. of Timken-Detroit Axle Co.), 36-15—47th Ave., Long Island City; *for mail,* 110-18—72nd Ave., Forest Hills, L. I.

JACOBSON, Frank ('16; '26), Pres., Seamlex Corp., 5-19—48th Ave.

JANOUSEK, Jos. (J'26), Time Stands. Engr., West. Elec. Co., Inc., 100 Central Ave., Kearny, N. J.; *for mail,* 4602—25th Ave., Long Island City, N. Y.

KELLER, Fred'k J. ('31), Dist. Ch. Engr., Breyer Ice Cream Co., 3409 Queens Blvd., Long Island City; *for mail,* 7035 Broadway, Jackson Heights, L. I.

KLAUS, Louis J. ('34), Ch. Engr., Metropolitan Div., Timken Silent Automatic Co. (Div. of Timken-Detroit Axle Co.), 36-17—47th Ave.

KLEIN, Bernard D. ('23), Pres., Gas Purifying Materials Co., Inc., Foot of Halsey St.; *for mail,* 30-34—36th St.

KUSHNICK, Wm. H. (J'26), Asst. Gen. Supt., Anchor Cap & Closure Corp., 22 Queen St.

La FETRA, C. W ('20; '35), Engr., Charge Estimating, Ford Instrument Co., Inc., Rawson St. & Nelson Ave., Long Island City; *for mail,* 103 Kellogg St., Oyster Bay, L. I.

LAND, Chester B. (J'30), Asst. Prod. Engr., Westinghouse X-Ray Co., Inc., 21-16—43d Ave.

LAWRENCE, James V. ('36), Ch. Draftsman, Ford Instrument Co., Inc., Rawson St. & Nelson Ave.; *for mail,* 2718—14th St.

LERCH, Werner E. ('36), Natl. Ch. Engr., Hemphill Diesel Schs., 31-28 Queens Blvd.

LIGHT, Harold B. (J'36), V. P., Prod. & Sales, Light Corrugated Box Corp., 3702 Northern Blvd.

LUCY, Sam G. (J'33), 3060—29th St.

MacDONALD, Murray J. ('23; '35), Factory Mgr., Natl. Casket Co., Inc., 29-76 Northern Blvd.

MARSH, Harry S. ('19), Engr., Ford Instrument Co., Inc., Rawson St. & Nelson Ave., Long Island City; *for mail,* 230 Shoreward Dr., Great Neck, L. I.

MAYHEW, Benj. Alan ('20; '33), Supt. Power, Natl. Sugar Refining Co. of N. J., Long Island City, N. Y.; *for mail,* 21 Ravine Rd., Tenafly, N. J.

McCAMMOND, Walter W. (J'33), Detailer, Arma Engrg. Co., 254—36th St., Brooklyn; *for mail* 45-55—39th St., Long Island City.

McDOWELL, Robt. W. (J'30), Jr. Engr., Ford Instrument Co., Inc., Rawson St. & Nelson Ave.

MILFORD, Albert M. (J'30), Mgr., Change Order Dept., Gen. Bronze Corp., 34-19—10th St., Long Island City; *for mail,* 146-21 Willets Point Blvd., Flushing, L. I.

MILLS, Harold H. (J'13), Executive, Dryden & Palmer, Inc., 44-02—23rd St.

MULE, Anthony (J'35), 23-12—31st Ave.

MURPHY, Robt. E. ('36), Head, Methods Dept., Am. Chicle Co., Thomson Ave. & Manly St., Long Island City; *for mail,* 42-53 Layton St., Elmhurst, L. I.

MYERS, Curtis C. ('05; '20), Ford Instrument Co., Inc., Rawson St. & Nelson Ave., Long Island City; *for mail,* 89-16—148th St., Jamaica, L. I.

OREN, Stanley E. (J'32), M. E., Plant Maint., Am. Chicle Co., Thomson Ave., Long Island City; *for mail,* Apt. C-32, 3419—90th St., Jackson Heights, L. I.

PEPPER, Edw. (J'34), Inspr., Waldes-Koh-i-noor, Inc., 47-52—27th St., Long Island City; *for mail,* 528 W. 111th St., New York.

PINNEY, Ernest F. ('23; '25; '35), M. M., Pratt Wks., Socony-Vacuum Oil Co., Inc., Review Ave.

RICHARDS, Gerald R. (J'24), Supt. Factory, Am. Chicle Co., Long Island City; *for mail,* 32-27—153d St., Flushing, L. I.

SEGUSO, Oswald (J'28), Mech. Draftsman, Anchor Cap & Closure Co., Queens St., Long Island City; *for mail,* 1235—80th St., Brooklyn.

SMITH, Randolph M. (J'35), Tech. Instr., Hemphill Diesel Schs., 31-28 Queens Blvd.

SMITH, Roy E. (J'36), Jr. Engr., Shop & Drafting Wk., Natl. Elec. Instrument Co., 36-16 Skillman Ave., Long Island City; *for mail,* 110 Parsons Dr., Hempstead, L. I.

THOMAS, Thos. R. ('30), Ch. Engr., Bijur Lub. Corp., 22-08—43d Ave., Long Island City; *home address,* 70 Marble Hill Ave., New York.

VARGA, Gideon M. (J'29), Time Study Dept., Neptune Meter Co., 192 Jackson Ave., Long Island City; *for mail,* 563 Cauldwell Ave., New York.

Von TILL, Louis A. ('23; '31; '35), Engr., Anchor Cap & Closure Corp., 22 Queens St., Long Island City; *for mail,* 71 Stevenson St., Lynbrook, L. I.

WHITE, Raymond E. ('20), 3128 Queens Blvd.

WILHELM, John ('23; '35), Estimator, M. E., Charge Design & Constr., Cole Duncan Boiler Wks., Inc., 25-61 Borden Ave.

LYNBROOK, L. I., Metropolitan Section

BAKER, R. M. (J'34), Chart Draftsman, McCann-Erickson, Inc., 285 Madison Ave., New York; *for mail,* 27 Newton Ave., Lynbrook, L. I.

BAUMANN, Geo. W. ('21; '27; '35), Buyer, L. I. Lighting Co., 50 Church St., New York; *for mail,* 36 Curtis Pl., Lynbrook.

GUDEN, Jack C. (J'34), Salesman, A. B. Murray Co., Inc., 147 Wolcott St., Brooklyn; *for mail* 52 Roosevelt Ave., Lynbrook.

NORDSTROM, R. F. (J'26), Engr. Cost Analysis, Ford Instrument Co., Inc., Rawson St. & Nelson Ave., Long Island City; *for mail,* 29—1st St., Lynbrook.

SCHUBERT, Frank J. ('27; '33; '35), Design Engr., Loose-Wiles Biscuit Co., Long Island City; *for mail,* 102 Blossom Heath Ave., Lynbrook.

VOPAT, Wm. Arthur (J'31), Asst. Engr., Universal Cooler Corp., 332 Merrick Rd., Lynbrook; *for mail,* 86-15 Bretton Ave., Elmhurst, L. I.

LYON MOUNTAIN

EVANS, Henry J. ('27), Hotel Chateaugay.

MAHOPAC FALLS, Metropolitan Section

WILLIAMS, Paul M. J. (J'32), Box 71.

MALVERNE, L. I., Metropolitan Section

ROGERS, Walter S. (J'35), 31 Drake St.

MAMARONECK, Metropolitan Section

MARKS, H. J. ('07), 86 Palmer Ave.
WARREN, Aldred K. ('12), Retired; Shore Acres.

MANHASSET, L. I., Metropolitan Section

PARTHESIUS, H. J. ('15; '25), 122 Hillcrest Ave.

MARINERS HARBOR, S. I., Metropolitan Section

BRILL, Philip B. ('28), Naval Arch., Charge Design, United Shipyards, Inc.
NIELSEN, Jens ('22), Asst. to Pres., United Shipyards, Inc., Mariners Harbor; *for mail,* 52 Moody Pl., W. Brighton, S. I.
REICHELT, Clarence V. ('26; '33; '35), Planning Engr., United Shipyards, Inc., Mariners Harbor; *for mail,* 120 Kingsley Ave., Westerleigh, S. I.

MASPETH, L. I., Metropolitan Section

HOPKINS, Arthur G. ('33; '35), Plant Engr., Metal Package Corp., 5208 Grand St.
MERRILL, Geo. H. ('98; '17), Pres., Merrill Bros., 56-02 Arnold Ave.
PUSNIKAS, Kazys A. ('28; '35), Ch. Designer & M. E., Metal Package Corp., Grand St. & Garrison Ave., Maspeth; *for mail,* 109-34—156th St., Jamaica, L. I.

MASSENA

RICHARDSON, Francis E. (J'35), Draftsman, Aluminum Co. of Am.; *for mail,* 17 W. Orvis St.
STICKLEY, Paul E. (J'32), Apprentice Engr., Cable Research, Aluminum Co. of Am.; *for mail,* 10 Warren Ave.

MEDINA

CHATER, John A. ('27; '32), Ch. Engr., Charge Design, Prod. & Plant Engrg., Niagara Sprayer & Chem. Co., Inc., Middleport; *for mail,* 504 Park Ave., Medina.

MIDDLEPORT, Buffalo Section

GORMEL, Ernest M. (J'32), Engrg. Dept., Charge Mech. Prod. Order Writing, Niagara Sprayer & Chem. Co., Inc.; *for mail,* 22 State St.

MIDDLETOWN

BRADNER, Alton F. (J'32), Engr., Plant Cable Maps, Orange County Telephone Co., 19 John St.; *for mail,* 13½ Little Ave.
FELLOWS, Olin B. ('19; '35), Pres., Ideal Wrapping Mch. Co., 81 Sprague Ave.

MIDDLE VILLAGE, L. I., Metropolitan Section

WEISMANTLE, Arthur R. (J'36), Serv. Engr., Serv. Dept., Foster Wheeler Corp., Carteret, N. J.; *home address,* 66-60—69th St., Middle Village, L. I., N. Y.

MILLERTON

MYERS, Wm. J. (J'34), Millerton, Dutchess Co.

MINEOLA, L. I., Metropolitan Section

BROWN, Lewis F. ('30), Supt., Bldg. & Field Maint., Roosevelt Field, Inc.; *for mail,* Roosevelt Field.
FRAUENTHAL, Henry L. ('31; '34; '36), Asst. Hydro. Investigator, Dept. of County Engr., Court House.
HENDRICK, Wallace M. (J'12), Contr., 1527 Franklin Ave.
NEILSON, Wm. J. ('29), Oper. Engr., L. I. Lighting Co., Mineola; *for mail,* Box 202, Glenwood Landing, L. I.
REYLING, Geo. ('20), 214 Pomander Rd.

MONGAUP VALLEY

DEL FUNGO-GIERA, Philip ('19), Research Engr., Mongaup Valley, Sullivan Co.

MONROE

HORNER, Edwin F. ('21; '23), Box Y.

MONTOUR FALLS, Ithaca Section

FOX, Ralph W. (J'35), Draftsman, Estimating Dept., Shepard Niles Crane & Hoist Corp., Montour Falls; *for mail,* 116 N. Monroe St., Watkins Glen.
PRICE, Lewis ('24; '35), Engr., Charge Design, Shepard Niles Crane & Hoist Corp.
WALTON, R. W. ('24), Ch. Draftsman, Engrg. Dept., Shepard Niles Crane & Hoist Corp.

MONTROSE, Metropolitan Section

SCHOENFELD, Edw. Jr. (J'36), 3d Asst. Engr., Isthmian Steamship Co., 71 Broadway, New York; *for mail,* Lancaster Ave., Montrose.

MOUNTAIN VIEW

HARDING, Frank Welland ('96), Retired; Mountain View, Franklin Co.

MOUNT VERNON, Metropolitan Section

BARLOW, Thaddeus S. ('23), Supt. Prod., Consltd. Edison Co. of N. Y., Inc., 20th Ave. & 21st St., Astoria, L. I.; *home address,* 531 E. Lincoln Ave., Mt. Vernon.
BOOS, J. Augustus (J'31), 328 S. 2nd Ave.
BREUNICH, Paul E. (J'26), 616 E. Lincoln Ave.
BROWN, Mortimer C. ('15; '35), M. E., 137 Summit Ave.
FEHER, Leslie L. (J'31), Engrg. Asst. Westchester Lighting Co., Rm. 1003, 9 S. 1st Ave., Mt. Vernon; *for mail,* 740 E. 243rd St., New York.
HOLLANDER, Emanuel ('01; '06), Cons. Engr., 153 Hillside Ave.
JOHNSON, Meredith G. (J'34), 303 Sheridan Blvd.
KINDERMANN, Wilfred J. (J'36), 7 La Belle Rd.
LATHAM, B. W. ('16), 22 E. Grand St., Fleetwood.
MEDCALF, Lloyd C. (J'26), 11 W. Prospect Ave.
PEYSER, Jos. ('22; '35), Pres., Mch. Designer, Peyser-Hansen Mch. Co., 10-12 Brookdale Pl.
STECK, Robt. C. (J'36), 242 S. Columbus Ave.
STEGMANN, Geo. H. ('19; '35), 472 Gramatan Ave.
STRUTHERS, Royden T. ('17; '35), Sales Engr., Stand. Oil Co. of N. Y.

NEWARK, Rochester Section

INMAN, Wm. H. ('22; '35), Inventing, Designing, Bloomer Bros. Co.; *for mail,* 127 Grant St.

NEWARK VALLEY, Ithaca Section

PAUL, John W. ('95; '96), Retired.

NEWBURGH, Metropolitan Section

BILLIPP, Ernest H. ('21), V. P., Gen. Mgr., Turl Iron & Car. Co., Inc.
ELDRIDGE, Frank G. (J'30), M. E., Coldwell-Wilcox Co.; *for mail,* 20 Farrell St.
HEIDENREICH, E. Lee, Jr. ('31), Ch. Engr. & Gen. Supt., N. Y. Trap Rock Corp., 252 Water St.

NEW DORP, S. I., Metropolitan Section

BUCKLER, Albert ('05; '25; '35), 62 Jaques Ave.
PETER, Bert H. (J'30), Devel. Engr., S. S. White Dental Mfg. Co., Prince Bay; *for mail,* 129 8th St., New Dorp.

NEW ROCHELLE, Metropolitan Section

ANTHONY, Gardner C. ('84), Dean Emeritus, Tufts College; *for mail,* 5 Circuit.
ARCHIBALD, Fred A., Jr. (J'34), 43 Lafayette St.
BELINE, Martin B. (J'33), Design Engr., Stand. Air Conditioning, Inc.; *for mail,* 10 Heminway Ave.
BRUSH, C. Benj. ('31), Secy., Treas., Factory Mgr., Modern Brands, Inc., 412 Halsey St., Newark. N. J.; *for mail,* 40 Maywood Rd., New Rochelle, N. Y.
BUCKLEY, Guidet M. ('22; '25; '35), 151 Centre Ave.
CRAIG, Jas. ('97), 100 Pelham Rd.
EASTON, Edw., Jr. (J'30), Engr., Design, 5 Schley Ave.
EKLUND, Joel ('25), 54 Mountain Ave.
FLYNN, J. Harold (J'23), 30 Albermarle Ave.
FOSTER, Geo. T. (J'32), Jr. Engr., Prat-Daniel Corp., 84 S. Water St., Port Chester; *for mail,* 197 Elm St., New Rochelle.
HEDLEY, Watler H. (J'26), 53 Trenor Dr.
KIMBER, Harry A. ('21), Dist. Sales Agent, Sims Co., Erie, Pa.; *for mail,* 33 Elk Ave., New Rochelle, N. Y.
KROTO, Geo. ('08), 29 Mt. Joy Pl.
McKENZIE, John C. S. ('17; '21), Lubrication Engr., Socony-Vacuum Oil Co., Inc., 112 State St., Albany; *for mail,* 11 Hubert Pl., New Rochelle.
MORRISSEY, Peter J. ('13), 19 Holly Dr.
PAPE, Paul F. ('23; '35), 569 Webster Ave.
PARKINSON, Roger W. (J'27), M. E., Am. Sugar Refining Co., 49 S. 2nd St., Brooklyn; *for mail,* 837 Webster Ave., New Rochelle.
STEVENS, Geo. E. (J'29), 69 Lincoln St.
TRENCK, Emil F. (J'34), Draftsman, J. M. Lehmann Co., Inc., New York Ave., Lyndhurst, N. J.; *for mail,* 41 Hillside Ave., New Rochelle, N. Y.
VINCENT, Arthur S. ('09; '23), 57 French Ridge.
WARD, Howard B., Jr. (J'31), 229 Paine Ave.

NEW YORK, Metropolitan Section

AARFLOT, Martin G. ('31), Gibbs & Cox, 31 West St., New York, N. Y.; *for mail,* 121 Washington St., E. Orange, N. J.
ABBEY, Harold G. (J'34), Engr., Charge Constr., Design, Breuer Engrg. Co., Inc., 101 W. 31st St., New York; *for mail,* 625 E. 96th St., Brooklyn.
ACHESON, John M. ('22; '26; '32), M. E., Charge Utility Relations, Natl. Biscuit Co., 449 W. 14th St.
ADAMS, Arthur H. ('22), Cons. Engr., 420 Lexington Ave.
ADDAMS, Homer ('28), Pres., Kewanee Boiler Co., Inc. & Fitzgibbons Boiler Co., Inc.; *for mail,* 101 Park Ave.
AHLQVIST, Harald ('09), Cons. Engr., 331 Madison Ave.
AHRENS, Carl ('32; '35), Asst. Plant Supt., Bound Brook, N. J., plant of Am. Cyanamid Co. (Beetle Products Div.), 30 Rockefeller Plaza, New York, N. Y.; *for mail,* 217 E. 7th St., Plainfield, N. J.
AITKEN, Saml. ('21; '24), V. P., Moore & McCormack Co., Inc., 5 Broadway, New York, N. Y.; *for mail,* 100 Woodland Ave., E. Orange, N. J.
AKABANE, Seiichi (J'26), Design Engr., Nakajima Aircrafts Wks., Mitsui & Co., Ltd., Empire State Bldg., New York; *for mail,* 5 Manning Circle, Pelham.
ALDRICH, Henry E. ('19; '25), Secy., A. B. M. A. Fair Practice Committee, 15 Park Row.
ALDRIN, Capt. Edwin E. ('19; '28), Aviation Mgr., Stand. Oil Devel. Co., 26 Broadway.
ALFORD, L. P. ('00; '08; 'F'36), Vice-President, '20-'22; *Melville Medallist,* '27; Ronald Press Co., 15 E. 26th St.
ALLARDICE, Thos. B. ('29), M. E., Design & Maint., Am. Gas & Elec. Co., 30 Church St.
ALLEN, Frank C., Jr. ('23), Owner, Sales Engrg. Agency, 480 Lexington Ave.
ALLEN, LeRoy V. (J'29), Salesman, Curtis Pneumatic Mchy. Co., 30 Church St., New York, N. Y.; *for mail,* Gilbert Rd., Hohokus, N. J.
ALLEN, Oliver Field ('17), Cons. Engr., 117 Liberty St.; *for mail,* 59 W. 44th St.
ALLMAN, Wm. N. ('27), Asst. to V. P., Johns-Manville Sales Corp., 22 E. 40th St.
ALLSTRUM, L. S. (A'32), Gen. Mgr., Geo. H. Morrill Co., 100—6th Ave.
ALMIRALL, Juan ('92; '04), 53 Park Pl.
ALMOIAN, Nerses A. (J'29), 550 W. 184th St.
ALRICH, Herbert W. ('15), Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.
ALSBERG, Julius ('05; '19), Cons. Chem. Engr., 114 E. 32nd St.
ALTIN, Alex. (J'29), Mech. Draftsman, Dept. Water Supply, Municipal Bldg.; *for mail,* 245 Wadsworth Ave.
ALTON, David Elie (J'34), 810 Gerard Ave.
ANDERSON, Geo. Philip ('35), Cons. Engr., Chas. E. Bedaux Co. of N. Y., 22 E. 40th St., New York, N. Y.; *for mail,* 461 Station Ave., Haddonfield, N. J.
ANDERSON, Gustave A. ('20; '35), M. E., Internatl. Handkerchief Mfg. Co., 137th St. & Willow Ave.; *for mail,* 4004 Rombouts Ave.
ANDERSON, John N. ('14), M. E., Otis Elev. Co., 260—11th Ave., New York, N. Y.; *for mail,* 905 Castle Point Terrace, Hoboken, N. J.
ANDREINI, Jos. I. (J'32), 22 E. 47th St.
ANDREW, Jas. D. ('04), Mgr., Am. Boiler Mfrs. Assn., 15 Park Row.
ANDREWS, John W. ('29), Cons. Refrig. Engr., Clyde-Mallory Lines, Pier 34, North River.
ANGELORO, Aniello (J'28), Asst. Supt., Charge Constr., U. S. Wks. Progress Admin., Arthur Ave.; *for mail,* 856 E. 217th St.
ANGUS, Wm. N. (J'25), Wm. Angus, Inc., 15 E. 40th St.
ANTONUCCI, Bartholomew J. (J'36), 4441 Broadway.
APPLEBAUM, Saml. B. ('21; '35), V. P., Permutit Co., 330 W. 42nd St.
ARCHDEACON, Howard K. (J'33), Repairman, N. Y. Tel. Co., 140 West St., New York; *for mail,* 28 Niles Pl., Yonkers.
ARCHIBALD, Wm. D. (J'34), Inspr., Hartford Steam Boiler Inspc. & Ins. Co., 90 John St., New York, N. Y.; *for mail,* 100—2nd Ave., Newark, N. J.
ARKEBAUER, Jesse O. ('21), Mar. Surveyor, Cons. Engr., 15 Moore St.
ARMACOST, Wilbur H. ('17; '21; '35), Ch. Engr. Indus. Dept., Superheater Co., 60 E. 42nd St.
ARMENTROUT, Horace L., Jr. (J'36), Apprentice Engr., Babcock & Wilcox Co., 85 Liberty St. New York, N. Y.; *for mail,* 184 N. 6th St. Barberton, Ohio.
ARMITAGE, Henry B. ('22), V. P., Engrg. Salesman, Baker, Smith & Co., 576 Greenwich St. New York; *for mail,* 12 Spruce Rd., Larchmont
ARMS, John H. R. ('23; '31), Secy., Gen. Mgr. United Engrg. Trustees, Inc., 29 W. 39th St. *for mail,* 31 E. 39th St.
ARMSTRONG, Clarence E. ('22; '35), Comptroller Burns Bros., 50 Church St., New York, N. Y. *for mail,* 38 Morton Pl., E. Orange, N. J.
ARMSTRONG, Geo. S. ('13; '21), Geo. S. Armstrong & Co., Inc., 40 Wall St.
ARMSTRONG, Jos. G. (J'33), 2350 Davidson Ave

ARNSTEIN, Leonard A. ('15; '21), Mech. Draftsman, Grade 4, Dept. Sanitation, Div. Engrg., Room 802, 125 Worth St.

ASCH, Abraham B. (J'30), Ch. Designer, Filtration Equipment Corp., 10 E. 40th St.

ASHLEY, Edw. E., Jr. ('10; '14; '16), Cons. Engr., 10 E. 40th St.

ASHLEY, Frank M. (J'94), Pat. Solicitor, 655—6th Ave.

ATKINS, David Fowler ('07), Cons. Engr., 2842 Grand Central Terminal Bldg., New York; *for mail,* 144-47—37th Ave., Flushing, L. I.

ATKINS, Harold B. ('03), Cons. Accountant, 120 Broadway.

ATKINSON, Herbert S. ('15), Mgr., Clam Shell Bucket Dept., Hayward Co., 50 Church St.

AUSTIN, Harold R. ('16), M. W. Kellogg Co., 225 Broadway.

AUTENRIETH, Geo. C. ('08; '14), Prof. Mech. Drawing & Mch. Design, College of the City of N. Y., 139th St. & Convent Ave.

AVERY, Walter R. ('31), Partner, W. R. Avery & Co., Cons. Engrs., 55 W. 42nd St.

AVERY, Whitney K. (J'21), Engr., Holmes Elec. Protective Co., 370—7th Ave., New York, N. Y.; *for mail,* 16 Carol Lane, Bergenfield, N. J.

AVNSOE, Thorkild ('13; '16; '22), Gen. Supt., Lone Star Cement Corp., 342 Madison Ave.

AYARS, Wm. Stewart ('13), Assoc. Prof. Indus. Engrg., Columbia Univ., Broadway at 117th St.

BACKUS, Richard A. ('21), Chief Engr., Charge Structural Design, Voorhees, Gmelin & Walker, 101 Park Ave.

BACON, Geo. W. ('98; '99), Chmn., Bd. of Dir., Ford, Bacon & Davis, Inc., 39 Broadway.

BAER, Carl A. ('23), Exec. V. P., Loose Leaf & Blank Book Inst., Inc., 342 Madison Ave.; *for mail,* 310 E. 44th St.

BAETZ, Henry ('33), Combustion Engrg. Co., Inc., 200 Madison Ave.; *for mail,* Hotel Robt. Fulton.

BAILEY, E. G. ('03; '12), V. P., Charge Engrg., Babcock & Wilcox Co., 85 Liberty St.

BAILEY, Eugene G. ('27), Rm. 2700, 52 Wall St.

BAKER, Albert L. ('36), M. E. Design, M. W. Kellogg Co., 225 Broadway.

BAKER, Chas. Whiting ('93; F'36), Vice-President '09-'11; 90 West St., New York, N. Y.; *for mail,* 20 S. Mountain Ave., Montclair, N. J.

BAKER, Douglas B. ('28), Asst. to Pres., Internatl. Stand. Elec. Corp., 67 Broad St.

BAKHMETEFF, Boris A. ('31), Chmn. Bd., Treas., Lion Match Co., 250 W. 57th St.

BAKRADZE, John ('24; '35), 813 Park Ave.

BALCH, Wm. (J'28), Engr., Gas Dept., Dover Boiler Wks., 50 Church St.; *for mail,* 31 Post Ave.

BALDWIN, Preston De G. (J'34), Pres., Baldwin Belting & Leather Co., Inc., 85 Chambers St.

BALL, Herman F. ('13), Pres., Franklin Ry. Supply Co., 60 E. 42nd St.

BALLANTINE, John H. ('17; '27; '35), V. P., Charge Sales, Neptune Meter Co., 50 W. 50th St.

BALLARD, Levi ('24; '31; '35), Supvg. Indus. Engr., Tide Water Oil Co., 17 Battery Pl., New York; *for mail,* 51 S. Forest Ave., Rockville Centre, L. I.

BALOGH, Stephen I. ('27), Cons. Engr., Charge Constr. & Maint., Crystal & Crystal, 47 West St.; *for mail,* 454 Riverside Dr.

BANCKER, Jas. W. ('13), V. P., West. Elec. Co., Inc., 195 Broadway.

BANGSER, Wm. ('31), Secy., Charge Prod., H. Maimin Co., Inc., 571—8th Ave.

BANNERMAN, Chas. R., Jr. (J'35), Salesman, Repairman, United Carr Fastener Corp., 15 E. 26th St., New York, N. Y.; *for mail,* 106 S. Harrison St., E. Orange, N. J.

BARBE, Martin (J'36), M. E., Euthenics Products Corp., Denville, N. J.; *for mail,* 314 W. 77th St., New York, N. Y.

BARBIERI, Cesare ('08), Cons. Engr., 340 Park Ave.

BARBOUR, Robt. ('16; '24), Pres., Linen Thread Co., Inc., 60 E. 42nd St.

BARKER, Harry ('22), Mem. Firm, Barker & Wheeler, 11 Park Pl., New York, N. Y.; *for mail,* 201 N. Mountain Ave., Montclair, N. J.

BARKER, Jos. Warren ('30), Dean, Sch. of Engrg., Columbia Univ., 417 W. 117th St.

BARKER, Tom ('22; '35), Engr., Charge Plant Design, United Parcel Serv., 331 E. 38th St.

BARNARD, Norris C. ('20; '25; '35), Sales Engr., Internatl.-Stacey Corp., 420 Lexington Ave., New York, N. Y.; *for mail,* 803 Boulevard, Westfield, N. J.

BARNES, Howell H., Jr. ('10), Commercial V. P., Gen. Elec. Co., 570 Lexington Ave.

BARNHART, Clarence D. ('20), Secy., Sales & Design, W. S. Rockwell Co., 50 Church St.

BARNSLEY, Herbert J. ('19; '35), Sales Engr., Jenkins Bros., 80 White St.

BARR, S. D. ('21; '27), Mgr., N. Y. Dist., Graver Tank & Mfg. Co., Inc., 424 Madison Ave.

BARRETT, S. K. ('30), Asst. Dean, College of Engrg., Charge Evening Div., N. Y. Univ., University Heights.

BARRETT, Wm. F. ('15), V. P., Union Carbide & Carbon Corp., 30 E. 42nd St.

BARRETT, Wm. J. ('19; '26; '35), Mgr., Policyholders Serv. Bur., Metro. Life Ins. Co., 1 Madison Ave.

BARRON, Claude M. ('10; '14; '35), Pur. Agent, Consltd. Railroads of Cuba, 70 E. 45th St.

BARSTOW, Francis L. ('05; '11), Mgr., Paper Mill Sales, U. S. Rubber Products, Inc., 1790 Broadway.

BARTELT, Paul ('25), Cons. Engr., 5008 Broadway.

BASSETT, W. G. R. ('29), Ch. Engr., Bush Terminal Co., Foot 43d St., Brooklyn; *for mail,* 438 W. 116th St., New York.

BATEMAN, Geo. F. ('21), Dean & Prof. M. E., Schools of Engrg., Cooper Union.

BAUER, Harry J. ('23; '35), M. E., N. Y. Steam Corp., 280 Madison Ave., New York, N. Y.; *for mail,* 135 Sunset Lane, Tenafly, N. J.

BAUMAN, Edw. ('21), Secy., Werner Nygren, Inc., 101 Park Ave.

BAUMANN, Howard (J'29), Asst. Plant Engr., Vadsco Sales Co., 21-09 Borden Ave., Long Island City; *for mail,* 1250 Taylor Ave., New York.

BAUMEISTER, Paul A. ('18; '35), M. E., Ingersoll-Rand Co., 11 Broadway, New York; *for mail,* 3367—162nd St., Flushing, L. I.

BAUMEISTER, Theo., Jr. ('23; '30), Asst. Prof. M. E., Columbia Univ., Pupin Physics Labs., 120th St. & Broadway.

BAXLEY, C. Herbert ('22; '27; '30), Staff Engr., Sinclair Refining Co., 45 Nassau St., New York, N. Y.; *for mail,* 11 Burnham Pl., Fair Lawn, N. J.

BEARDSLEY, Harry Irving ('19; '35), Supvr., Design Engr., Bell Tel. Labs., Inc., 463 West St., New York, N. Y.; *for mail,* 5 Dempster Rd., Chatham, N. J.

BEAUCHEMIN, A. O. ('21), Executive, Layne-New York Co., Rm. 1702, 92 Liberty St.

BECHERT, Fred J. ('14; '20; '35), Mem. Firm, Mitchell & Bechert, 420 Lexington Ave.

BECK, Lawrence J. (J'35), 10 W. 48th St.

BECKER, Julius ('23), M. E., Engrg. Dept., Semet-Solvay Engrg. Corp., 40 Rector St.

BEGLEY, Richard W. ('21), Supt. Engr., Booth Am. Shipping Corp., 17 Battery Pl.

BELL, Andrew F. ('23), Grand Hotel, 31st St. & Broadway.

BELL, Andrew L. ('13; '19), Plant Engr., Charge Constr. & Maint., Barrett Co., Edgewater, N. J.; *for mail,* 69 Tieman Pl., New York, N. Y.

BELL, Harold S. ('21; '23), Cons. Petroleum Engr., 1136 Woolworth Bldg.

BENEDETTI, Geo. G. ('30; '35), Spec. Staff Engr., N. Y. Cent. R. R. Co., Grand Central Terminal, New York, N. Y.; *for mail,* 42 Hill St,, Bogota, N. J.

BENNETT, Daniel A. ('30; AM'35), Hawson & Hawson, 1 Cedar St., New York; *for mail,* 8407—105th St., Richmond Hill, L. I.

BENNETT, Geo. W. (J'32), Sales Engr., Feedwaters, Inc., 140 Cedar St., New York, N. Y.; *for mail,* Box 106, Woodcliff Lake, N. J.

BENNETT, Henry G. ('24; '35), Ch. Inspc. Engr., Charge Piping Design, Installations, N. Y. Steam Corp., 280 Madison Ave.; *for mail,* 40 Earley St., City Island.

BENNETT, L. W. ('18; '35), Valuation Engr., Edw. J. Cheney, 61 Broadway; *for mail,* 420 W. 24th St.

BENNETT, Thos. A. ('03; '21), Mgr. Belting Sales, Belt Engr., U. S. Rubber Products, Inc., 1790 Broadway; *for mail,* 27 Washington Sq., N.

BERAN, Chas. F. ('27), Cons. Engr., Celanese Corp. of Am., 180 Madison Ave.

BERGER, Geo. G. (J'36), 710 Riverside Dr.

BERGQUIST, John G. ('12), 500—5th Ave.

BERGSETH, Robt. A. (J'36), 215 W. 23 St.

BERNNER, Milton St. J. ('18; '25; '35), M. E., Charge Maint., Pace Inst., 225 Broadway, New York; *for mail,* 88-18 Whitney Ave., Elmhurst, L. I.

BERNSTEIN, Edwin J., Jr. (J'33), 450 West End Ave.

BEROLZHEIMER, Henry ('18; '25; '35), Secy., Treas., Eagle Pencil Co., 710 E. 14th St.

BERRESFORD, Arthur W. ('11), 50 Central Park W.

BERRY, Francis R. ('26), Asst. Ch. Engr., Am. Water Wks. & Elec. Co., 50 Broad St.

BESSIO, Oscar (J'33), Engrg. Asst., Jacobs Bros. Scale Co., Brooklyn; *for mail,* 1908 McGraw Ave., New York.

BETTMAN, Robt. ('23; '34; '35), Engr. of Purchasing, Pac. Commercial Co., 120 Wall St., New York, N. Y.; *for mail,* 68 Garden St., Hoboken, N. J.

BETTS, Walter L. ('16; '22; '35), Supvr., Bell Tel. Labs., Inc., 463 West St., New York; *for mail,* 167 Maple St., Brooklyn.

BETZLER, Henry W. ('34; '35), Engr., Charge Elec. Div., Research Dept., N. Y. Steam Corp., 416 E. 36th St.

BIDSTRUP, Herluf A. (J'32), M. E., F. L. Smidth & Co., 225 Broadway.

BIELEK, Arthur Ernest ('31; '35), Instr. Mech. Drafting, Mechanics Inst., 18-24 W. 44th St., New York; *for mail,* 2333 Foster Ave., Brooklyn.

BIGGE, Jos. ('23; A'24), Designer, Whaley Eng. Pats., Rm. 2443, 17 Battery Pl., New York; *for mail,* 2063 West St., Brooklyn.

BILLEY, Peter R. (J'35), Engr., Gen. Chem. Co., 40 Rector St.; *for mail,* Apt. 5A, 431 W. 121st St.

BILLINGS, Edw. J. ('12; '17), Exec. Asst., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail,* 109 Park Ave., Verona, N. J.

BILLITCH, Harry (J'32), 1558 Bryant Ave.

BLACK, Alex. R. (J'25), Sales Engr., Shell Union Oil Corp., 50 W. 50th St.

BLACK, Archibald ('21), Engrg. Asst., Port of N. Y. Authority, 111—8th Ave., New York; *for mail,* 116 Sackville Rd., Garden City, L. I.

BLACKBURN, Chas. H. ('15; '24; '35), Pres., Treas., Dir., Mgr., Hormiguero Cent. Corp., 60 Beaver St.

BLACKMAN, Alfred O. ('22), Cons. Engr., Apt. 3D, London Terrace, 450 W. 24th St.

BLACKSHAW, Joe (J'29), Air Conditioning Engr., Air & Refrigeration Corp., Rm. 1482, 11 W. 42nd St., New York; *for mail,* 59 Joralemon St., Brooklyn.

BLAKE, John H., Jr. ('32), Pres., Ch. Engr., Simplex Oil Htg. Corp., 30 Church St.

BLANCHARD, Rollo Kimball ('12; '14; '25), V. P., Neptune Meter Co., 50 W. 50th St.

BLANKSTEEN, Saul C. (J'36), Truck Maint. Asst., Dept. of Sanitation, 125 Worth St.; *for mail,* 946 Leggett Ave.

BLISS, Collins P. ('03), Pres., Engrg. Index, Inc., 29 W. 39th St., New York; *for mail,* Eton Hall, Scarsdale.

BLISS, Harold D. ('19), V. P., East. Mgr., B. P. Lientz & Co., Suite 1204, 1270 Broadway.

BLITZ, Emmanuel ('31; '35), M. E., Charge Mech. Design, Real Estate & Maint. Dept., Emergency Relief Bur., 902 Broadway; *for mail,* 1388 Prospect Ave.

BLIZARD, John ('20), Head, Research Dept., Foster Wheeler Corp., 165 Broadway, New York; *for mail,* 7 Cedar Pl., Garden City, L. I.

BLOCH-HILLER, Walter ('26; '35), Cons. Engr., 5th Ave. Bank, 530—5th Ave.

BLOCK, Edw. L. (J'30), Asst. Valuation Engr., N. Y. Pub. Serv. Comm., 80 Centre St.; *for mail,* 1109 Clay Ave.

BLOSSOM, Francis ('02), Partner, Sanderson & Porter, 52 William St.

BLUM, Jos. K. ('09; '19; '26), Cons. Engr., 205 E. 42nd St.

BOCK, Kurt G. W. ('27; '35), Mgr., Hesser Mch. Co., 30 Church St.

BOEHM, Wm. H. ('00), Retired; 260 Convent Ave.

BOEHRINGER, Hans (J'30), Sales Engr., United Am. Bosch Corp., 17 W. 60th St.

BOGGS, Robt. W. ('26; '30; '35), Tech. Publicity Dept., Union Carbide Co., 205 E. 42nd St., New York; *for mail,* 472 Morris Ave., Rockville Centre, L. I.

BOLIN, Marcel E. ('26; '35), 2728 Spuyten Duyvil Pkwy.

BOLTON, Reginald P. ('98), Treas., Elec. Meter Corp., Bolton Bldg., 116 E. 19th St.

BOND, P. Clark ('25; '34; '35), M. E., M. W. Kellogg Co., 225 Broadway, New York; *for mail,* Maple Ave., E. Hempstead, L. I.

BOND, R. Elliott ('27), 205 E. 78th St.

BORGSTEDT, Henning N. ('19), Mgr., N. Y. District, Frick Co., 370 Lexington Ave., New York; *for mail,* 390 N. Broadway, Yonkers.

BORLAND, John ('32), 25 E. 9th St.

BOTTA, Angelo (J'36), 411 W. 44th St.

BOTWINICK, B. (J'36), 1494 Crotona Pk., E.

BOURNE, Geo. L. ('03), Chmn. Bd., Superheater Co., 60 E. 42nd St.

BOWER, Jerome G. (A'03), Sales Agent, Buckeye Steel Castings Co., 50 Church St.

BOYD, John T., ('87), Purchasing Agent, Cons. Engr., Textile Banking Co., Inc., 55 Madison Ave.; *for mail,* 123 E. 40th St.

BOYD, Willard A. ('15), Sales Engr., Struthers Wells Co., 285 Madison Ave., New York; *for mail,* 22 Pendleton Pl., New Brighton, S. I.

BOYE, Burton L. ('25), Mgr., Fuel Oil Dept., Socony-Vacuum Oil Co., Inc., 26 Broadway.

BOYER, Edwin S. ('97; '02; '07), Pres., Am. Hard Rubber Co., 11 Mercer St., New York, N. Y.; *for mail,* 1070 Hillside Ave., Plainfield, N. J.

BRAILO, G. P. ('36), Amtorg Trading Corp., 261—5th Ave.

BRAINE, Bancroft G. ('96; '05), Engr., Charge Engrg. Dept., Rail Joint Co., 50 Church St.

BRAINE, Daniel L. ('25), Rail Joint Co., 70 Pine St., New York; *for mail,* 115 Willow St., Brooklyn.

BRAND, Geo. B. ('12), 12 W. 40th St.; *for mail,* 419 W. 22nd St.
BRANDIN, Wm. H. ('28; '29), Engr., Charge Installations, Clyde R. Place, 420 Lexington Ave., New York; *for mail,* 200 Rutland Rd. Brooklyn.
BRANDT, Carl A. W. ('16), Ch. Engr., Superheater Co., 60 E. 42nd St., New York; *for mail,* 8 Hilltop Dr., Great Neck, L. I.
BRAY, Compton D. ('26), V. P., Mead-Morrison Mfg. Co., 220 E. 42nd St., New York; *for mail,* 8 Hawthorn Rd., Larchmont.
BREAKEY, Geo. M. ('31), Cons. Engr., 43 W. 86th St.
BREAZNELL, Jos. G. ('27), Engr. (Mgmt. Studies). Am. Cyanamid Co., 30 Rockefeller Plaza, New York; *for mail,* 6 Chelsea Dr., Port Washington, L. I.
BRECKENRIDGE, C. E. ('04; '16), Ch. Engr., Charge Maint., Am. Express Co., 65 Broadway.
BREEN, Patrick J. ('31; '35), Ch. Engr., S. S. Beaconhill, Stand. Oil Co. of N. J., Mar. Dept., 30 Rockefeller Plaza.
BREHM, Wm. W. ('28; '34; '35), 434 W. 25th St.
BRENNER, Melvin M. (J'35), 652 Southern Blvd.
BREWER, Allen F. ('16; '19; '26), M. E., Tex. Co., 17 Battery Pl., New York, N. Y.; *for mail,* 41 Winding Way, W. Orange, N. J.
BRIGGS, Kendal L. (J'36), Field Engr.. Constr. Dept., Raymond Concrete Pile Co., 140 Cedar St.; *for mail,* 2823 University Ave.
BRINKMAN, Chas. F. (J'36), Treas., Rossell, Brinkman & Herrmann, Inc., 110 West End Ave., New York, N. Y.; *for mail,* 70 Lindsley Ave., Newark, N. J.
BRINTON, Willard C. ('07; '12), Pres., Treas., Terminal Engrg. Co., Inc., 599—11th Ave.
BRISTOL, Raymond W. ('19; '35), Pres., Bristol & Raaen, Inc., 124 W. 31st St.
BRIZZOLARA, Robt. T. ('17; '26), Pres., Charge Refrigeration, R. B. Engrg. Corp., 75 West St., New York; *for mail,* 44 Vincent Ave., Staten Island.
BROCINER, Victor (J'31), Design Engr., Luxtrol Co., Inc., 205 W. 19th St.; *for mail,* 412 Cathedral Pkwy.
BROCKLEBANK, Arthur P. ('12), Ch. Engr., Cameron Pump Div., Ingersoll-Rand Co., 11 Broadway, New York, N. Y.; *for mail,* 59 Baldwin Pl., Elizabeth, N. J.
BRODER, Chas. (J'34), 250 Ft. Washington Ave.
BRODERICK, Jos. F. ('30; '35), Constr. Engr., S. H. Sweeney, Inc., 306 E. 39th St., New York, N. Y.; *for mail,* West Ave., Springdale, Conn.
BROMBERG, Jacob ('32; '35), M. E., Design, Natl. Transit Pump & Mch. Co., 30 Rockefeller Plaza, New York; *for mail,* 88-14—214 Pl., Queens Village, L. I.
BROMLEY, Chas. H. ('19; '35), Lubrication Engr., Pure Oil Co., 420 Lexington Ave.
BROOKS, Fred'k T. (J'36), Engr., Design Dept., Gruenwald & Niemitz, 153-7 Greene St., New York; *for mail,* 381 Bristol St., Brooklyn.
BROOKS, Jas. G. (J'36), Dist. Mgr., Cleaver-Brooks Co., 30 Church St.
BROUGHTON, Wm. W. ('31; '35), Tech. Serv. Dept., N. J. Zinc Co., 160 Front St.
BROWN, Clinton B. ('17; '35), 1435 Lexington Ave.
BROWN, Dickson Q. ('02; '14), Rm. 828, 342 Madison Ave.
BROWN, Geo. L. ('28; '32; '35), Pur. Engr., Consltd. Laundries Corp., 122 E. 42nd St., New York; *for mail,* 42 Edna St., Baldwin, L. I.
BROWN, Howard H. ('08; '25), Editor, Marine Engrg. & Shipping Review, Simmons-Boardman Publ. Co., 30 Church St.
BROWN, Jacob H. ('19; '35), 1240 Walton Ave.
BROWN, John J. ('02), Chmn. Bd., Foster Wheeler Corp., 165 Broadway.
BROWNE, Bard ('20; '35), Asst. to V. P., Superheater Co., 60 E. 42nd St., New York; *for mail,* 71 Flower Ave., Hastings-on-Hudson.
BRUCE, Alfred W. ('14), Designing Engr., Am. Loco. Co., 30 Church St.
BRUCKNER, Arthur ('19), Prof. M. E., College of the City of N. Y., 139th St. & Convent Ave., New York; *for mail,* 162 Villard Ave., Hastings-on-Hudson.
BRUEHL, Lawrence ('30; '35), M. E., Taco Heaters, Inc., 342 Madison Ave.; *for mail,* 132 W. 95th St.
BRUNE, Carleton E. ('22; '27; '35), Job. Engr., Phœnix Engrg. Corp., 2 Rector St., New York, N. Y.; *for mail,* 95 Highland Ave., Metuchen, N. J.
BRUNING, John M. ('31; '35), Maint. Engr., Spear & Co., 225—5th Ave., New York; *for mail,* 3925—65th St., Woodside, L. I.
BRYDEN, Colby W. (J'23), Mgr., Oil Purification Dept., De Laval Separator Co., 165 Broadway, New York, N. Y.; *for mail,* 137 Washington St., Westfield, N. J.
BUBAR, Hudson H. ('19; '21), 15 Park Row.
BUEHNER, Wm. F. A. ('33; '35), Pat. Developer, Rm. 306, 236 W. 55th St.; *for mail,* 118 W. 81st St.
BUENSOD, Alfred C. ('15; '27), Pres., Buensod-Stacey Air Conditioning, Inc., 60 E. 42nd St.; *for mail,* 1—5th Ave.
BUHRENDORF, Fred'k G. ('26; '32; '35), Design Engr., Bell Tel. Labs., Inc., 463 West St.
BULLOCK, Harry Leslie ('21; '26; '35), Owner, H. L. Bullock, Equip. Sales, 50 Church St.; *for mail,* 452 Riverside Dr.
BUNGE, Ralph W. ('15; '26), Asst. Cons. & Supvg. Engr., Stand. Brands, Inc., 595 Madison Ave.
BUNNELL, Sterling H. ('94; '03), Secy., Geo. S. Armstrong & Co., Inc., 52 Wall St., New York, N. Y.; *for mail,* 2225 Main St., Stratford, Conn.
BURKE, John J., Jr. (J'34), Bell Tel. Labs., Inc., 463 West St. New York; *for mail,* 117-40—224th St., St. Albans, L. I.
BURKE, Thos. F. ('21), Asst. Engr., Car Equip., Interborough Rapid Transit Co., 2545—7th Ave.
BURNETTE, A. R. ('20), Professional Engr., 52 William St.
BURNS, A. L. ('88; '97), Director, Jabez Burns & Sons, Inc., 600 W. 43 St.
BURNS, Alan Elmer ('24; '35), Mgr., Oil Burner Dept., Warren-Norge Co., Inc., 315—4th Ave., New York; *for mail,* 83-11—34th Ave.. Jackson Heights, L. I.
BURNS, Alan Elwin ('20; '35), Utility Mgmt. Corp., 150 Broadway.
BURNS, Arthur E. (J'31), Lubrication Engrg. Com., A.S.M.E., 29 W. 39th St., New York; *for mail,* 1958 E. 29th St., Brooklyn.
BURNS, Edwin F. (J'21), Steam Engr., Internatl. Paper Co., 220 E. 42nd St., New York; *for mail,* Apt. D, Kensington Court, Glens Falls.
BURSTEIN, Adolph (J'32), Stress Analyst, Seversky Aircraft Corp., Farmingdale, L. I.; *for mail,* 17 W. 125th St., New York.
BUSHNELL, Douglas S. ('09), Pres., N. Y. Transit Co., 26 Broadway.
BUTLER, Henry W. ('24), M. E., Sanderson & Porter, 52 William St.; *for mail,* 150 E. 73rd St.
BUTLER, Wiley H. ('29; '35), Diesel Engr., Stand. Oil Co. of N. J., 26 Broadway.
BUTT, Howard ('22; '23), N. Y. Mgr., Wm. Powell Co., 50 Church St.
BYER, Henry E. ('19), Mgr., Byer Engrg. Associates, 21 State St.
CADY, Cecil I. ('22), Cons. Engr., 101 Park Ave.
CAHILL, John E. ('18; '35), Partner, John E. Cahill Co., 342 Madison Ave.
CALAMARI, Peter L. (J'34), 201 E. 127th St.
CALDWELL, Wm. E. ('18; '22; '26), *Melville Medallist,* '33; Efficiency Engr., N. Y. Edison Co., Inc., 4 Irving Pl.
CALLAHAN, Vincent T. ('30), Reserve Power Plant Engr., Bell Tel. Labs., Inc., 463 West St., New York, N. Y.; *for mail,* 331 Morningside Terrace, Teaneck, N. J.
CALLAWAY, Clarence R. ('21), Pres., Gurney Elev. Co., Inc., 109 W. 64th St.
CAMPBELL, David S. (J'32), Devel. Engr., Rockwood & Co., 88 Washington Ave., Brooklyn; *for mail,* 40 Monroe St., New York.
CAMPBELL, Donald ('14), Pat. Lawyer, 2402 Graybar Bldg., Lexington Ave. & 43rd St.
CAPO, Jos. J. (J'36), 213 E. 34th St.
CARIS, Ivan B. ('12), Engr., Estate Planning, John Hancock Mutual Life Ins. Co., 225 Broadway, New York; N. Y.; *for mail,* 73 Ely Pl., E. Orange, N. J.
CARLE, Arthur B. ('28), A. B. Carle Co., Power Plant Equip., 39 Cortlandt St.
CARLSON, Harold C.-R. (J'34), M. E., Otis Elev. Co., 260—11th Ave.; *for mail,* 130 W. 16th St.
CARLSON, Harry ('21; '35), Sales Engr., Bakelite Corp., 247 Park Ave.
CARMAN, Jos. F. ('18; '35), Ch. Engr., Charge Maint., Metro. Life Ins. Co., 1 Madison Ave., New York; *for mail,* 158—73rd St., Brooklyn.
CARNEY, Jos. F. ('15), Supvg. Engr. Hotel Waldorf Astoria, Park Ave.; *for mail,* 1749 Grand Concourse.
CARNEY, Wm. H. ('23; '33), C. P. A., Cost Consultant; 420 Lexington Ave., New York; *for mail,* 4134 Case St., Elmhurst, L. I.
CARPENTER, Harold ('08), Asst. to Constr. Engr., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl., New York; *for mail,* 538 Westchester Ave., Port Chester.
CARPENTER, Henry A. ('93; '99), Yale Club, Vanderbilt Ave. & 44th St.
CARPENTER, Howard Baylis ('25; '27), Sales Engrg. Div., Standard Oil Co. of N. J., 26 Broadway.
CARRICK, Gerald S. ('19), Gen. Mgr., Indus. Dept., Am. Arch Co., 60 E. 42nd St.
CARROLL, Jas. D. (J'30), Mech. Draftsman, Dept. of Sanitation, Bur. Incinerators & Garages, 125 Worth St., New York; *for mail,* 6061 Gates Ave., Ridgewood, L. I.
CARROLL, Morris B. ('11; '17), Gen. Mgr., La Mont Corp., 92 Liberty St., New York, N. Y.; *for mail,* 718 E. Broad St., Westfield, N. J.
CARTER, Douglas S. (A'23), Sales Engr., Superheater Co., 60 E. 42nd St., New York; *for mail,* 6 Ridgecrest E., Scarsdale.
CARTER, Emmett B. ('12), New York, N. Y.; *for mail,* 19 Prospect St., Tenafly, N. J.
CARTER, R. Jefferson ('35; '35), M. W. Kellogg Co., 225 Broadway
CARTER, Robt. A., Jr. ('16), Engr. of Mfr., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.
CARVER, Fred S. ('16; '21), 345 Hudson St., New York, N. Y.; *for mail,* P. O. Box 49, Short Hills, N. J.
CASEY, J. Schuyler ('27), Pres., M. H. Treadwell Co., Inc., 140 Cedar St.
CASSIDY, Perry ('13; '26), Exec. Asst., Babcock & Wilcox Co., 19 Rector St.
CASSOTTI, Mario (J'32), Engr., Tide Study, U. S. War Dept.; *for mail,* 106 E. 116th St.
CETRULE, John (J'18), Mgr., Triplex Mch. Tool Corp., 125 Barclay St.
CHAMBERLAIN, Alex S. (J'26), Partner, Staff Engr., Emerson Engrs., 30 Rockefeller Plaza.
CHAMBERS, Norman C. ('05; '14), Engr., Foreign Div., Chicago Pneumatic Tool Co., 6 E. 44th St.
CHANG, Kwang Hwa (J'28), Draftsman, Topographical Div., Dept. of Parks, 79th & Riverside Dr.; *for mail,* 431 W. 121st St.
CHAPIN, Warren W. ('17), Cons. Engr., 153 E. 38th St.
CHAPMAN, Cloyd M. ('10), Cons. Engr., 230 W. 41st St.
CHARAVAY, Marius A. ('08; '25; '35), Mem. Firm, Stevens & Legg, 25 Broad St., New York., N. Y.; *for mail,* 50 Anderson St., Hackensack, N. J.
CHASE, Horace H. ('30), Mem. Firm, Nicholas S. Hill, Jr., 112 E. 19th St., New York, N. Y.; *for mail,* Box 252, Sandwich, Mass.
CHAVE, Chas. T. (J'29), Process Engr., Alco Products, Inc., 30 Church St.; *for mail,* 140 E. 46th St.
CHAVE, Walter E. ('21), Pres., McQuillen & Chave, Inc., 198—11th Ave.
CHEEVER, Markham ('01), Elec. Bond & Share Co., 2 Rector St.
CHERDANTZEFF, Peter ('22; '25; '35), Asst. Engr., N. Y. Edison Co., Inc., 4 Irving Pl.; *for mail,* 3647 Broadway.
CHESLER, Isidor ('21; '35), M. E., Charge Research, Devel. & Mfg., Eagle Pencil Co., 710 E. 14th St.
CHION, Frederic V. (J'33), 3211 Seymour Ave.
CHRISTENSEN, C. H. (J'33), Salesman, Natl. Carbon Co., Inc., 30 E. 42nd St., New York; *for mail,* 4 Maple Dr., Great Neck, L. I.
CHURCH, Austin H. ('28; '34; '36), Instr., Mch. Design & Kinematics, Cooper Union, Astor Pl.
CHURCHILL, Wm. L. ('19), Propr., W. L. Churchill, 52 Vanderbilt Ave.
CHUTE, Stanley J. ('14; '20; '30), Ch. Engr., Hea[t] Transfer Div., Alco Products, Inc., 30 Church St., New York, N. Y.; *for mail,* 312 Linwood Ave., Ridgewood, N. J.
CILLEY, Raymond ('14), Exper. Wk., F. L. Smith Mch. Co., 635 W. 44th St., New York, N. Y.; *for mail,* 1238 Alicia Ave., W. Englewood, N. J.
CIZEK, Albert W., Jr. (J'35), Engrg. Draftsman & Estimator, Richmond Screw Anchor Co., Inc., 245 Bush St., Brooklyn; *for mail,* 415 E. 71st St., New York.
CLARK, Frank H. ('10), Cons. Engr., 949 Broadway.
CLARK, Jas. M. (J'28), Aero. Pat. Engr., Mfrs. Aircraft Assn., 30 Rockefeller Plaza.
CLARK, Peter J. ('32), Draftsman, Fire Dept., New York; *for mail,* 155 Willoughby Ave., Brooklyn.
CLARK, S. C. (J'30), Tech. Publicity Dept., Union Carbide Co., 205 E. 42nd St., New York; *for mail,* 26 Winthrop Ave., Larchmont.
CLARK, Walter L. ('88), Retired; Engineers' Club, 32 W. 40th St.
CLARKE, Chas. M. ('29; '35), Engrg. Dept., Turbine Inspc., Fidelity & Casualty Co. of N. Y., 80 Maiden Lane, New York; *for mail,* 90 New York Ave., Baldwin, L. I.
CLARKE, Walter J. ('14), Dist. Mgr., Anchor Packing Co., 100—6th Ave., New York, N. Y.; *for mail,* 398 Thornden St., S. Orange, N. J.
CLEM, Dallas W. ('24; '35), V. P., Mgr., Reeves Pulley Co. of N. Y., Inc., 76 Dey St., New York, N. Y.; *for mail,* 50 Lexington Ave., Bloomfield, N. J.
CLEMMER, Albert J. (J'22), Asst. to Supt., Insp. for Mazda Serv., Elec. Testing Labs., 80th St. & East End Ave., New York; *for mail,* Apt. 1[…] 28 Caryl Ave., Yonkers.
CLINEDINST, Wendel W. ('21; '25; '30), Pres., West Engrg. Corp., 4109 Woolworth Bldg., New York; *for mail,* 1806 Caton Ave., Brooklyn.
COATES, Henry T. ('27), Pur. Agt., Dairymen's League Cooperative Assn., Inc., 11 W. 42nd St.
COBURN, Frederic G. ('12; '13), Mem. Firm, Sanderson & Porter, 52 William St.
CODDING, E. Hale ('25), Indus. Engr., Tide Water Oil Co., 17 Battery Pl.
COES, Harold V. ('07; '13; F'36), Vice-President, '27; Manager, '29-'32; Vice-President, '32-'3[…] Mgr., Indus. Dept., Ford, Bacon & Davis, Inc., 39 Broadway.

COFFIN, Frank M. ('07), Estimator & Sales Engr., Peerless Elev. Co., 71—8th Ave., New York; *for mail,* 110 Hillside Ave., Mt. Vernon.
COFFIN, Howard E. ('07), Chmn. Bd., Southeast Cottons, Inc., 58-60 Worth St.; *for mail,* Engineers' Club, 32 W. 40th St.
COHEN, E. F. ('16; '21; '35), Mem. of Staff, A. Eugene Michel & Staff, 132 E. 31st St., New York; *for mail,* 539 Webster Ave., New Rochelle.
COHEN, Emanuel M. ('21; '26; '30), Asst. Gen. Mgr., Park Central Hotel, 56th St. & 7th Ave.
COLBY, Haldwell S. ('27), Gen. Sales Mgr., Combustion Engrg. Co., Inc., 200 Madison Ave., New York; *for mail,* 104 Franklin Ave., Yonkers.
COLDWELL, E. S. ('20; '26), Ford, Bacon & Davis, Inc., 39 Broadway.
COLE, Carter Stanard ('30; '35), Engr., Copper & Brass Research Assn., 420 Lexington Ave.
COLE, Edw. S. ('97; '06), Hyd. Engr., Pres., Pitometer Co., Rm. 668, 50 Church St.
COLEMAN, Francis A. (J'32), Res. Mgr., Racolin Mgmt. Co., 1221 College Ave.; *for mail,* 2980 Valentine Ave.
COLEMAN, Philip L. ('24; '32; '35), Shelton Hotel, 527 Lexington Ave.
COLLORA, Nicholas A. (J'33), Engr., Process Dept., M. W. Kellogg Co., 225 Broadway, New York; *for mail,* 55 Hanson Pl., Brooklyn.
COLVIN, Fred H. ('95; '99), Editor, Am. Machinist, McGraw-Hill Publ. Co., Inc., 330 W. 42nd St.
COMSTOCK, Louis K. ('02), Chmn., Bd. Dirs., L. K. Comstock & Co., 71 Broadway.
CONDIT, Kenneth Hamilton ('21; '28), Manager, '36-'39; Editor, Am. Machinist, McGraw-Hill Publ. Co., Inc., 330 W. 42nd St., New York, N. Y.; *for mail,* 34 Westcott Rd., Princeton, N. J.
CONHAGEN, Alfred ('22; '31; '35), Sales Engr., U. S. Metallic Packing Co., Rm. 836, 30 Church St.
CONLON, Wm. T. ('21; '25; '33), Mgr., Indus. Dept., Superheater Co., 60 E. 42nd St.
CONNOLLY, J. Wilford (J'25), M. E., Griscom-Russell Co., 285 Madison Ave., New York, N. Y.; *for mail,* 539 Palisades Ave., Teaneck, N. J.
CONNOR, Nicholas J. ('27; '35), Sales Engr., Babcock & Wilcox Co., 85 Liberty St., New York; *for mail,* 175 Bell Rd., Scarsdale.
CONOVER, Frank H. ('26), Asst. to Ch. Engr., Dorr Co., 570 Lexington Ave.
CONRAD, Hugh V. ('87; '91), Retired, 120 E. 39th St.
CONTANT, P. M. ('32), Ch. Engr., Neckar Co., Inc., 67 Wall St.
COOK, Laurie A. ('23; '30), M. E., Combustion Engrg. Co., Inc., 200 Madison Ave.; *for mail,* 116 W. 34th St.
COOK, Olney B. (J'27), Design Engr., Outside Plant, Bell Tel. Labs., Inc., 463 West St.
COOK, Wm. Pierson, Jr. ('11; '13; '29), V. P., Charge Sales, Wm. P. Cook & Co., Inc., 19 W. 44th St.
COONEY, Francis J. ('35), Exec. V. P., Columbia Presbyterian Medical Center, 168th St. & Broadway, New York; *for mail,* 721 Jefferson Ave., Brooklyn.
COONLEY, Howard (A'17), Pres., Walworth Co., 60 E. 42nd St.
COONRADT, Arthur C. ('25; '35), Assoc. Prof., Heat-Power Engrg., Chmn. M. E. Dept., N. Y. Univ., University Heights; *for mail,* 1921 Andrews Ave.
COOPER, Benj. ('36), Gen. Mgr., Tallo & Cooper, 103 Lafayette St.; *for mail,* 170 W. 74th St.
COOPER, Frank P. ('21; '30), Ch. Engr., J. Edw. Ogden Co., 147 Cedar St., New York, N. Y.; *for mail,* Box 26, Bayonne, N. J.
COOPER, Howard (J'17), Asst. Mgr., Domestic Lub. Sales, Sinclair Refining Co., 630—5th Ave.
COOPER, Hugh L. ('13), Pres., Hugh L. Cooper & Co., Inc., 101 Park Ave.
CORINTH, Thos. (J'34), Butler Hall, 88 Morningside Dr.
CORNWELL, Hobart V. ('14; '24), Cons. Engr., H. V. Cornwell & R. E. Greuter, 570 Lexington Ave., New York; *for mail,* 117 Marvin Ave., Hempstead, L. I.
CORY, David Cleveland (J'34), Asst. to V. P., Peter, Cailler, Kohler Swiss Chocolates Co., 60 Hudson St., New York, N. Y.; *for mail,* 42 Dana Pl., Englewood, N. J.
COSTER, Eric H. ('10), Engr., Mech. Design, Interborough Rapid Transit Co., 600 W. 59th St., New York, N. Y.; *for mail,* 445 Lawn Ridge Rd., Orange, N. J.
COTTRELL, Nicholas (J'33), Mgr., Research Dept., Amerika-Interessen, Chrysler Bldg.; *for mail,* 920—5th Ave.
COVEY, Kenneth S. ('36), Business Mgr., Veterans Admin., 130 W. Kingsbridge Rd.
COX, Abraham B. ('14), Cons. Engr., 149 Broadway, New York; *for mail,* Cherry Valley.
COX, James W. ('16; '21), Mfr., Iselin-Jefferson Co., 90 Worth St.
COZZENS, John H. ('21; '35), Pat. Solicitor, Bell Tel. Labs., Inc., 463 West St., New York; *for mail,* 22 Sprague Rd., Scarsdale.
CRAIG, Robt. ('18; '24), Pat. Atty., Cooper, Kerr & Dunham, 233 Broadway, New York, N. Y.; *for mail,* 41 Roosevelt Rd., Maplewood, N. J.
CRANE, Henry M. ('20), Tech. Asst. to Pres., Gen. Motors Corp., Broadway & 57th St.; *for mail,* 40 E. 54th St.
CRAVENS, Geo. W. ('18; '30), Business Research Engr., 270 Broadway.
CRAWFORD, Col. C. H. ('16), 1 W. 54th St.
CRISWELL, Wilbur W., Jr. (J'28), Mgr., Charge Combustion, Rochester & Pittsburgh Coal Co., 420 Lexington Ave.
CROCKETT, H. G. ('30; '35), McKinsey, Wellington & Co., 52 Wall St.
CROSBY, Edwin S. ('21), V. P., Johns-Manville Internatl. Corp., 22 E. 40th St., New York, N. Y.; *for mail,* 7 Washington Park, Maplewood, N. J.
CROSS, B. J. ('36), Asst. Engr., Research & Devel., Combustion Engrg. Co., Inc., 200 Madison Ave.
CROTTY, Jos. J. ('32), V. P., Cent. Fdy. Co., Graybar Bldg., 420 Lexington Ave.
CROVATTO, Philip R. ('32; '35), Draftsman, Design, Interborough Rapid Transit Co., Rm. 210, 2545—7th Ave.; *for mail,* 74 Clinton Pl.
CUDDEBACK, A. Elston (J'29), Field Engr., Sheffield Farms Co., 524 W. 57th St., New York; *for mail,* 36-22—208th St., Bayside, L. I.
CULLEN, Thos. J. (J'25), Sales Engr., Johns-Manville Internatl. Corp., 292 Madison Ave.; *for mail,* 2865 University Ave.
CUMMINGS, Jas. D. ('23; '31; '35), Member Tech. Staff, Bell Tel. Labs., Inc., 463 West St., New York; *for mail,* 3515—164th St., Flushing, L. I.
CUMMINGS, Orrie P. ('99), V. P., A. B. See Elev. Co., Inc., 419—4th Ave.
CUMMINGS, Robt. Felt ('23; '30; '35), Charge M. E. Dept., Burns & Roe, Inc., 233 Broadway, New York, N. Y.; *for mail,* 169 Grand Ave., Leonia, N. J.
CUMNER, Matthew S. ('12), V. P., Nestor Mfg. Co., Inc., 40 W. 13th St., New York; *for mail,* 2215 Newkirk Ave., Brooklyn.
CURIONI, Salvatore M. ('35), Engr., Charge Design, N. Y. City Omnibus Corp., 123 W. 146th St.; *for mail,* 37 W. 10th St.
CURRY, Malcolm ('17), Gen. Engr., Charge Power, Maint. & Design, Am. Thread Co., 260 W. Broadway.
CURTISS, Wesley L. ('28), M. E., Maint. of Way Dept., N. Y. Cent. R. R., 466 Lexington Ave.
CUSHING, Henry J. (J'22), Inspec. Engr., N. Y. Steam Corp., 280 Madison Ave., New York; *for mail,* 55 Jefferson Blvd., Annadale, S. I.
DALTON, Howard H. ('20), Power Engr., Am. Sugar Refining Co., 120 Wall St.
DALTON, Thos. E. ('34; '35), Prod. Mgr., Hearst Magazines, Inc., Rm. 508, 959—8th Ave.
DAME, Frank E. (J'33), Jr. Engr., Rate Engrg. Dept., N. Y. Edison Co., Inc., 4 Irving Pl.
DANNEMANN, Henry, II (J'33), M. E., Tide Water Oil Co., Bayonne, N. J.; *for mail,* 260 Fort Washington Ave., New York, N. Y.
DARBEE, Wm. ('00; '12), Ebasco Services, Inc., 2 Rector St.
D'ARCY, Albert J. (J'36), Asst. Estimator, White Constr. Co., 95 Madison Ave.; *for mail,* 141 E. 62nd St.
DASHIELL, W. W. ('90), Chmn. Bd. Dirs., N. Y. Lubricating Oil Co., 116 Broad St.
DASSO, David ('12; '21; '33), V. P., Charge Diesel Div., Amer. Loco. Co., 30 Church St.
DAVEY, Peter ('26; '35), Treas., Vibroscope, Inc., also Secy., Devel. & Sales, Electrocon Corp., 6 Varick St.
DAVID, Ernest V. ('29), Asst. Mgr., Applied Engrg. Dept., Air Reduction Sales Co., 60 E. 42nd St.; *for mail,* 155 E. 49th St.
DAVIDSON, C. L. ('21), Supt. Power Sta., Elec. Div., N. Y. Central R. R. Co., 149th St. & East River.
DAVIDSON, Wm. Andrew ('16), M. E., Singer Mfg. Co., 149 Broadway, New York, N. Y.; *for mail,* 35 Hillside Road, Elizabeth, N. J.
DAVIES, C. E. ('15; '23; '26), Secretary, A.S.M.E., 29 W. 39th St.
DAVIS, Arthur Councilman ('20; '22), Supt. Maint., Port Authority of N. Y., 111—8th Ave., New York, N. Y.; *for mail,* 73 Preston St., Ridgefield Park, N. J.
DAVIS, Geo. Henry ('13), Dir., Ford, Bacon & Davis, Inc., 39 Broadway.
DAVIS, Robt. W. (J'34), Radio Price Specialist, West. Elec. Co., Inc., Room 810, 195 Broadway.
DEAKIN, Harry ('23; '35), Sales Engr., Johns-Manville Corp., 22 E. 40th St., New York, N. Y.; *for mail,* 132 Indian Run Pk., Union, N. J.
DEAN, Dion K. ('12; '20), M. E., Foster Wheeler Corp., 165 Broadway, New York, N. Y.; *for mail,* 16 Pierpont St., Rahway, N. J.
DE BETHUNE, Gaston S. P. ('29), 114 E. 90th St.
DEBLOIS, Lewis A. ('30), Cons. Engr., 1227 Madison Ave.
DEBSKI, Theo. F. (J'34), Gen. Mgr., F. Debski, 45 University Pl.
DE CRECY, Jacques ('33), M. E., Charge Maint., N. Y. State Dept. of Labor, 80 Centre St.; *for mail,* 24 W. 45th St.
DEEDS, Col. Edw. A. (A'00), Vice-President, '21-'23; 20 Exchange Pl.
DE FLOREZ, Luis ('16; '21), Cons. Engr., 19 Rector St.
DEGEN, Jos. W. ('25; '30; '35), Supvg. Engr., Equitable Office Bldg. Corp., 120 Broadway.
DE LORENZI, Otto ('20; '22; '25), Asst. Gen. Sales Mgr., Combustion Engrg. Co., Inc., 200 Madison Ave.
DE MARCO, Ralph P. ('23; '24; '35), M. E., Barrett Co., 40 Rector St.; *for mail,* 108 Field Pl.
DEMAREST, Henry S. (A'14), Mgr., Greene, Tweed & Co., 109 Duane St., New York; *for mail,* 164 Fulton Ave., Hempstead, L. I.
DENISON, Griswold ('18), M. E., Charge Design & Constr. of Stas., N. Y. Steam Corp., 130 E. 15th St., New York, N. Y.; *for mail,* 17 N. Terrace, Maplewood, N. J.
DENNINGER, Elbert (J'33), Engrg. Asst., Power Plant Testing, N. Y. Edison Co., Inc., 801 E. 14th St., New York; *for mail,* 681 St. Johns Pl., Brooklyn.
DENTON, A. Penn ('26), Cons. Engr., Rigid Steel Conduit Assn., 17 E. 42nd St.
DEPPELER, John H. ('15; '23), Ch. Engr., Wks. Mgr., Metal & Thermit Corp., 120 Broadway.
DEREMER, Jay Grant ('13), Cons. Engr., 51 E. 42nd St.
DERONDE, Louis A. ('19; '35), Instr. Math., N. Y. Univ., 181st St. & University Ave.; *for mail,* 102 W. 183rd St.
DERRICK, Arthur E. (J'25), Mech. Designer, Elec. Bond & Share Co., 71 Broadway, New York, N. Y.; *for mail,* 80 Leslie St., E. Orange, N. J.
DETTLOFF, Adolph M. ('21; '25; '30), U. S. Dept. of Commerce, 734 Custom House; *for mail,* 601 W. 113th St.
DEVEREUX, Henry M. (J'33), Yacht Designer, 295 City Island Ave.
DE ZAFRA, Carlos ('24), Cons. Mech. & Indus. Engr., Prof. Engrg., N. Y. Univ., P. O. Box 19, University Heights, New York; *for mail,* 174 Merlin Ave., N., Tarrytown.
DICKERMAN, Wm. C. ('99; '07), Pres., Am. Loco. Co., 30 Church St.
DICKINSON, Geo. S. (A'30), Berwind White Coal Mining Co., 1 Broadway.
DICKSON, Chas. H. ('16; '26), V. P., Secy., Worcester Salt Co., 40 Worth St., New York, N. Y.; *for mail,* 248 Reynolds Terrace, Orange, N. J.
DIERCKX, Jules (A'21), 136 W. 16th St.
DIETRICH, Albert G. (J'31), 409 E. 146th St.
DIETZ, Carl F. ('03; '10), Cons. Engr., 120 Broadway.
DINGER, Henry C. ('24), N. Y. Yacht Club, 37 W. 44th St.
DITMARS, Walter E. ('29; '35), 230 Park Ave.
DMITRIEFF, Boris A. ('26; '31; '35), Designer, Mech. Engrg. Dept., N. Y. Edison Co., Inc., 4 Irving Pl.
DOCKSTADER, E. Kneale (J'34), M. E., Draftsman, Babcock & Wilcox Co., 85 Rector St.; *for mail,* Apt. 5F, 22 Grove St.
DODGE, Albert Cole ('08), V. P., Charge Mfg., Internatl. Stand. Elec. Corp., 67 Broad St.
DOHERTY, Henry L. ('03), Pres., Cities Service Co., 60 Wall St.
DOIG, Godfrey D. ('27; '35), 1152—3rd Ave.
DOLAN, Chas. H., II ('30), V. P., Intercontinent Corp., Rm. 4524, 30 Rockefeller Plaza.
DOMINGUEZ, Carlos E. (J'34), Draftsman & Designer, Dept. Pub. Wks., Office of Borough Pres. of Manhattan, 7 Hubert St.; *for mail,* 616 W. 137th St.
DONALD, Wm. J. (A'27), Natl. Elec. Mfrs. Assn., 155 E. 44th St.
DONOVAN, Edward L. (J'24), Engr., Combustion Engrg. Co., Inc., 200 Madison Ave., New York; *for mail,* 647 Warburton Ave., Yonkers.
DOPPEL, Leonard ('32), Gen. Mgr., Sun Rise Cab Corp., 603 W. 55th St.
DOUGHERTY, Wm. F., Jr. (J'36), Estimator, Natl. Process Co., 75 Varick St., New York; *for mail,* 3417 Glenwood Rd., Brooklyn.
DOUGHTY, Wm. F. ('99; '15), Suite 2824, 17 Battery Pl.
DOWLING, Donald L. ('26; '34; '35), Dist. Mgr., Roots-Connersville Blower Corp., 24 State St., New York, N. Y.; *for mail,* 135 Prospect St., Ridgewood, N. J.
DOWLING, Edw. D., Jr. (J'36), Paper Bag Mfrs. Inst., 369 Lexington Ave.
DOWNE, Edw. R. ('22), V. P., Engrg., Am. Gas Products Corp., 40 W. 40th St.

DOWNEY, W. W. ('22), Dir. Engrg., M. E., N. Y. Hospital, 523 E. 70th St.
DOWNS, Chas. R. ('32), V. P., Treas., Weiss & Downs, Inc., 50 E. 41st St.
DRAKE, Warren C. ('17), Pres., Furnace Engrg. Co., 5 Beekman St., New York; *for mail*, Center St., Cedarhurst, L. I.
DRUTZU, S. T. ('21; '35), Rate Engr. & Economic Studies, Ebasco Services, Inc., 2 Rector St.
DRYPOLCHER, Wm. (J'30), Ch. Engr., Markwell Mfg. Co., Inc., 200 Hudson St.
DUN, Henry W., Jr. ('35), Rm. 1531, 420 Lexington Ave., New York, N. Y.; *for mail*, Belden Hill, Wilton, Conn.
DUNCAN, John C. ('14), Partner, W. E. Hutton & Co., 14 Wall St.
DUNCAN, J. Ray ('20; '35), Carrier Corp., Rm. 408, Chrysler Bldg., 42nd St. & Lexington Ave.
DUNDORE, Raymond Daniel (J'30), Field Supvr., Charge Specialty Sales, Gulf Oil Corp., 17 Battery Pl., New York; *for mail*, 3720—84th St., Jackson Heights, L. I.
DUNLOP, Wm. C. ('14), Elec.-Mech. Engr., Parsons, Klapp, Brinckerhoff & Douglas, 142 Maiden Lane.
DUNN, Edw. L. ('13), Research Engr., Otis Elev. Co., 260—11th Ave., New York, N. Y.; *for mail*, 29 Burnett St., Livingston, N. J.
DUNN, Gano ('11), Life Member; Pres.; J. G. White Engrg. Corp., 80 Broad St., also, Chairman, Natl. Research Council, 43 Exchange Pl.
DUNNING, Harry ('28), Sales Rep., Dunning Lueckel Engrg. Co., 17 John St.
DURBIN, Paul C. (J'21), Engr., Installation Dept., West. Elec. Co., Inc., 395 Hudson St.
DURHAM, Edwin (J'29), Calculator, Heat Transfer, Babcock & Wilcox Co., 85 Liberty St.
DURKEE, Chauncey H. ('19; '35; '35), Ch. Engr., Fultograph, Inc., 342 Madison Ave.; *for mail*, 420 W. 24th St.
DURYEA, Albert A. (J'33), Belden Point, City Island.
DUTTON, Fred'k O. ('34), Linde Air Products Corp., 30 E. 42nd St., New York, N. Y.; *for mail*, 11 Oberlin St., Maplewood, N. J.
DVORAK, Geo. (J'34), 2334 Webster Ave.
DWYER, Paul Francis (J'30), Engr., E. R. Squibb & Son, 25 Columbia Heights, Brooklyn; *home address*, 31 Bank St., New York.
DYER, Wesley B. ('36), Rm. 6170, 30 Rockefeller Plaza.
DYER, W. E. S. ('27), Cons. Engr., Arch., 21 West St., New York, N. Y.; *for mail*, York Rd., Jenkintown, Pa.
EADIE, John G. ('17), Cons. Engr., Eadie, Freund & Campbell, 110 W. 40th St.
EARHART, Amelia (A'31), 2 W. 45th St.
EASTMAN, Chas. A. (J'35), Commercial Dept., Ebasco Services, Ltd., 2 Rector St.
EBEL, Wm. J. (J'26), Salesman, Colonial Beacon Oil Co., 155 E. 44th St., New York; *for mail*, 51 Ethelridge Rd., White Plains.
EBY, Earl E. ('18), Gen. Motors Export Co., 1775 Broadway.
EDELSTEIN, Abraham (J'35), 1129 Morris Ave.
EDWARDS, Harry D. ('18), Wks. Engr., Linde Air Products Co., 30 E. 42nd St.
EDWARDS, Wm. H. (J'21), Mem. Tech. Staff, Bell Tel. Labs., Inc., 463 West St., New York; *for mail*, 8 Wensley Dr., Great Neck, L. I.
EFFROSS, Max P. ('35), Ch. Draftsman, Natl. Sugar Refining Co., 55th Ave. & 2nd St., Long Island City; *for mail*, 309 W. 57th St., New York.
EHBRECHT, Adolf ('30; '36), Secy. & P. A., Gries Reproducer Corp., 463 E. 133rd St.
EIBSEN, Louis J. ('19), M. E., Charge Maint., Mason & Hanger Co., 500—5th Ave., New York, N. Y.; *for mail*, 793 Fairview Lane, Grantwood, N. J.
EICHLER, Alfred J. (A'21), V. P. & Gen. Mgr., Walworth Internatl. Co., 19 Rector St.
EIDMANN, Frank L. ('15; '20), Prof. M. E., Columbia Univ., 116th St. & Broadway, New York, N. Y.; *for mail*, 15 Princeton Ave., Princeton, N. J.
ELDRED, Byron E. ('99; '03), 51 E. 42nd St.
ELLICOTT, Chas. R. ('16), V. P., Westinghouse Air Brake Co., 350—5th Ave.
ELLIOT, Augustus H. ('14; '35), V. P., Am. Brake Shoe & Fdy. Co., So. Wheel Div., 230 Park Ave.
ELLIOTT, Louis ('23), Cons. M. E., Ebasco Services, Inc., 2 Rector St.
ELLIOTT, Robt. F. ('31; '36), Design Engr., Apparatus Devel. Dept., Bell Tel. Labs., Inc., 463 West St., New York, N. Y.; *for mail*, 10 Vreeland Terrace, Jersey City, N. J.
ELLIS, Clifford A. ('22), Ch. Engr., Socony-Vacuum Oil Co., Inc., 26 Broadway.
ELMER, Lloyd A. ('21; '36), Design Engr., Bell Tel. Labs., Inc., 463 West St.
ENDLICH, Wm. H. G. ('23), Asst. Leading Mech. Draftsman, N. Y. Edison Co., Inc., 4 Irving Pl., New York; *for mail*, 180 Saratoga Ave., Brooklyn.
ENGEL, Louis G. ('87), 22 E. 47th St.
ENO, Wilber S. (J'35), M. E., Tech. Staff, Bell Tel. Labs., Inc., 463 West St., New York; *for mail*, 9021—107th St., Richmond Hill, L. I.
EPLEY, Frederic I. ('28; '35), Engr., Superheater Co., 60 E. 42nd St.
EPSTEAN, Edw. ('31), Treas., Walker Engraving Corp., 141 E. 25th St.; *for mail*, 2 E. 86th St.
ERNST, Alfred F. ('09; '14), Pat. Atty. & Engr., Certainteed Products Corp., 100 E. 42nd St., New York, N. Y.; *for mail*, 179 Woodward Ave., Rutherford, N. J.
ERNST, Fred'k C. ('31), Ch. Engr., Jenkins Bros., 80 White St., New York; *for mail*, 199-08—100th Ave., Hollis, L. I.
ESHERICK, Geo., Jr. ('15; '20), M. E., Sanderson & Porter, 52 William St.
ESTABROOK, Mansfield ('03; '19), Brown, Wheelock, Harris Co., Inc., 22 E. 40th St.
ESTEP, Frank L. ('19), V. P., Perin Engrg. Co., 535—5th Ave.
EVANS, C. O. ('22; '35), Secy. & Condenser Tube Sales Engr., British Am. Tube Co., 40 Wall St.
EVANS, Earle R. ('23; '25), V. P., Charge Field Opera., McKiernan-Terry Corp., 15 Park Row.
EVANS, Francis C. (J'31), M. E., Charge Automatic Fire Alarm Section, Am. Dist. Telegraph Co., 155—6th Ave.
EVANS, Jonathan (J'29), 337 E. 30th St.
EVERETT, Allen ('30), Fed. Light & Traction Co., 70 Pine St.
EWALT, Newton C. (J'26), Sales Engr., Walworth Co., 60 E. 42nd St., New York; *for mail*, 66 Princeton Blvd., Kenmore.
FAHY, Jas. A. ('33), 164 W. 74th St.
FAILE, E. H. ('31), Designing & Constr. Engr., 608—5th Ave.
FAIRCHILD, Sherman M. (A'27), Pres., Fairchild Aviation Corp., 570 Lexington Ave.; *for mail*, 898 Park Ave.
FALES, Herbert G. ('21; '33), V. P., Internatl. Nickel Co., Inc., 67 Wall St.
FALKNER, Jefferson C. ('23; '35), Asst. to Research Engr., N. Y. Edison Co., Inc., New York; *for mail*, 3511—173rd St., Flushing, L. I.
FALLA, Fernando ('23), Engr., Foster Wheeler Corp., 165 Broadway, New York, N. Y.; *for mail*, 59 Elm St., Maplewood, N. J.
FALLON, David G. (J'30), Mech. Draftsman, Power Plant Design, Elec. Mgmt. & Engrg. Corp., Room 805, 84 William St., New York, N. Y.; *for mail*, 25 Boyd Ave., Jersey City, N. J.
FARDELMANN, John H., Jr. ('18; '22; '27), M. E., Charge Design, M. H. Treadwell Co., 140 Cedar St., New York, N. Y.; *for mail*, 217 Alexander Ave., Montclair, N. J.
FARMER, F. Malcolm ('15), V. P. & Ch. Engr., Elec. Testing Labs., 80th St. & East End Ave.
FARRELL, Jas. A., Jr. (J'24), Pres., Am. South African Line, Inc., 26 Beaver St.
FEE, Harold R. ('21; '28; '35), Sales Engr., Ingersoll-Rand Co., 11 Broadway, New York; *for mail*, 17 Wyndmere Rd., Mt. Vernon.
FELDMAN, Abram M. ('00), Cons. Engr., 40 W. 77th St.
FELKER, Geo. F. ('13; '15; '18), V. P., Gen. Sales Mgr., Crosby Steam Gage & Valve Co., 30 Church St.
FELL, Hugh P. ('15; '19), Asst. Ch. Engr., Borden Milk Co., 350 Madison Ave.
FERENZAK, Geo. W. (J'34), Machinist, N. Y. Hospital, Cornell Medical Centre, 575 E. 68th St., New York; *for mail*, 4759—98th Pl., Corona, L. I.
FERGUSON, Hardy S. ('99), Partner, Hardy S. Ferguson & Co., 200—5th Ave.
FERGUSON, Robt. B. ('19; '26), Ch. Engr., Gen. Chem. Co., 40 Rector St.
FERRERO, Henry (J'33), 1738 Adams St.
FERRIS, Edwin A. (J'24), Serv. & Erection, Combustion Engrg. Co., Inc., 200 Madison Ave., New York, N. Y.; *for mail*, 6 Hudson Ave., Ridgefield Park, N. J.
FERRY, John M., Jr. ('24; '35), Engr., Charge Bldg. Constr., N. Y. Tel. Co., 140 West St.
FICCO, Frank, Jr. (J'29), 2089 Arthur Ave.
FINE, Maurice E. (J'36), Owner, Blower Engrg. Co., 915 Broadway.
FINK, Geo. E. ('35), Engrs. Asst., Consldt. Edison Co. of N. Y., Inc., 4 Irving Pl., New York; *for mail*, 8823—238th St., Bellerose, L. I.
FINK, Milton (J'36), Jr. Engr., A. B. See Elev. Co., 150 Pacific Ave., Jersey City, N. J.; *for mail*, 1204 Shakespeare Ave., New York, N. Y.
FINKE, F. W., Jr. (J'28), 315 E. 238th St.
FINLAY, W. S., Jr. ('16; F'36), Manager, '22; Vice-President, '22-'24; Pres., West Penn. Elec. Co., 50 Broad St.
FISHER, David A. (J'31), Instr. M. E., Sch. of Tech., College of City of N. Y., 140th & Amsterdam Ave.; *for mail*, 9 Adrian Ave.
FISHER, Irving M. (J'34), 50 W. 90th St.
FISK, G. L. ('15; '19), 271 Central Park W.
FITERMAN, M. B. (J'36), 504 Grand St.
FITZPATRICK, Frank R. ('19), Asst. to Pres., Superheater Co., 60 E. 42nd St.
FITZSIMMONS, A. M. R. ('34; '35), Asst. Engr., N. Y. Edison Co., Inc., 4 Irving Pl.
FLACK, Alonzo ('15; '35), Trustee, Treas., Cons. Engr., Emerson Engrs., 30 Rockefeller Plaza.
FLAVIN, Edw. J. (J'36), 415 W. 115th St.
FLEET, Samuel ('19; '35), Engr., Estimator, S. L. Fleet Co., Inc., 51 Madison Ave.
FLEISHER, Walter L. ('18), V. P., Gen. Mgr., Cooling & Air Conditioning Corp., 11 W. 42nd St.
FLEMING, Henry S. ('03), Cons. Engr., 1 Broadway.
FLIFLET, Thorlief ('18; '35), Engrg. Dept., Am. Gas & Elec. Co., 30 Church St.
FLOCKHART, Jas. ('22; '35), Field Engr., United Elec. Light & Power Co., 201st St. & 9th Ave., New York; *for mail*, 115 Devoe Ave., Yonkers.
FLOOD, Henry ('16; '35), Partner, Murray & Flood, 369 Lexington Ave.
FLURI, C. Bruce (J'26), Oper. Mgr., Fred F. French Mgmt. Co., 5 Prospect Pl.; *for. mail*, 3822 Bailey Ave.
FLYNN, Chas. A. ('16), V. P., Charge Sales, Flynn-Hill Elev. Corp., 6 Howard St.
FLYNN, Walter H. ('35), Gen. Supt. M. P. & Rolling Stock., N. Y. Central R. R. Co., Room 1408, 466 Lexington Ave.
FOGELSON, Emile ('27), 3650 Bronx Blvd.
FOGG, Oscar H. ('07; '13), V. P., Consltd. Edison Co. of N. Y., Inc., 130 E. 15th St.
FOLTAN, Louis (J'35), Charge Physical Testing Gold Alloy, Julius Aderer, Inc., 115 W. 45th St.; *for mail*, 1151 Elder Ave.
FOLTZ, R. D. ('21; '25; '35), V. P., M. H. Detrick Co., 21 West St.
FORBES, J. B. ('35; '35), Engr., Charge Design, Heat Transfer Div., Alco Products, Inc., 30 Church St.
FORD, Howard ('25; '35), 1st Officer, Grace Line, 18 Hanover Sq., New York; *for mail*, 7501—4th Ave., Brooklyn.
FORD, Louis R. ('20), Editor, Diesel Publications, Inc., 192 Lexington Ave.
FORREST, Geo. Munro ('12), Assoc., Jackson-Babbitt, Cons. Engrs., 580—5th Ave., New York; *for mail*, Blind Brook Lodge, Rye.
FORSMAN, Elmer J. (J'29), Serv. Engr., Babcock & Wilcox Co., 19 Rector St., New York, N. Y.; *for mail*, 131 Farley Ave., Fanwood, N. J.
FOSTER, Albert C. (J'26), M. E., Charge Pulv. Fuel Design, Foster Wheeler Corp., 165 Broadway, New York, N. Y.; *for mail*, 633 Shackamaxon Dr., Westfield, N. J.
FOSTER, Esty ('25; '26; '35), c/o Ford, Bacon & Davis, Inc., 39 Broadway.
FOSTER, Richard E., Jr. (J'34), Oper., Dehydrating Unit, Sardik Lab., 45th St., New York; *for mail*, 299 Adelphi St., Brooklyn.
FOX, Alfred W. (J'27), Cons. Engr., Utility Consumers Serv., Inc., 470—4th Ave., New York; *for mail*, 43-21—72nd St., Woodside, L. I.
FRAINT, Saul (J'36), 29 W. 84th St.
FRANCISCO, Ferris L. R. ('06; '12), Sr. Partner, Francisco & Jacobus, 511—5th Ave.
FRANK, Max (J'33), Test Engr., Waterside Sta., Consltd. Edison Co. of N. Y., Inc., 708—1st Ave.
FRANK, Mrs. Olive E. ('27), Frank Engrg. Co., 11 Park Pl.
FRANK, Philip E. ('28; '34), Engr., Charge Refinery Practice, Consltd. Oil Corp., 630—5th Ave.
FRANK, Robt. M. (J'34), M. E., Design Dept., Babcock & Wilcox Co., 19 Rector St.; *for mail*, 1390 Nelson Ave.
FRANKENHOFF, Chas. A. ('19; '31), Pres., Dicalite Co., 120 Wall St., New York; *for mail*, 46 Barry Rd., Scarsdale.
FRASER, Oliver B. J. ('33), Supt., Tech. Serv., Mill Products, Internatl. Nickel Co., Inc., 67 Wall St.
FREAR, Hugo P. ('21), Cons. Naval Arch., Bethlehem Shipbldg. Corp.; *for mail*, 425 Riverside Dr.
FREED, Leonard J. ('24; '35), 1st Asst. Engr., Operation, Interborough Rapid Transit Co., 600 W. 59th St.
FREELAND, Emile C. ('19; '26; '35), Indus. Engr., W. R. Grace & Co., 7 Hanover Sq.
FREUND, Herman R. ('28), Wks. Mgr., Intertype Corp., 1440 Broadway, New York; *for mail*, 241 Sterling St., Brooklyn.

FREYERMUTH, Geo. H. (J'30), Engr., Product Application, Stand. Oil Co. of N. J., 26 Broadway.

FREYSCHMIDT, C. ('19; '29), Supt., H. R. H. Mgmt. Corp., 9 E. 40th St.; *for mail,* 15 W. 81st St.

FRIEDEBERG, Solon E. ('23; '34), V. P., Charge Sales, Franklin Engrg. Corp., 45 W. 45th St.

FRIEDMAN, Milton (J'33), Apt. 12A, 470 West End Ave.

FRIEND, Walter F. (J'13), Asst. M. E. (Consulting), Ebasco Services, Inc., 2 Rector St.; *for mail,* 9 W. 68th St.

FRISCH, Martin ('22; '29; '35), Ch. Engr., Steam Div., Foster Wheeler Corp., 165 Broadway.

FROMM, Hugo H. ('31), Engr., Fred S. Carver, 345 Hudson St., New York, N. Y.; *for mail,* 253 Lincoln Ave., Elizabeth, N. J.

FUHRMANN, Otto W. (A'29), Cons. Typographer, 26 Washington Pl., Dir., Div. of Graphic Arts, N. Y. Univ., New York; *for mail,* 52-10—94th St., Elmhurst, L. I.

FUNCH, ERIK E. ('22), Asst. Ch. Engr., Lone Star Cement Corp., 342 Madison Ave.

GABOR, Harry W. ('32), Safety Engr., N. Y. State Ins. Fund, 625 Madison Ave., New York; *for mail,* 17 Lawrence Ave., Tuckahoe.

GAILLARD, John ('28), M. E., Am. Stands. Assn., 29 W. 39th St.

GALLAGHER, John J. ('29), Pres. Goodwin-Gallagher Sand & Gravel Corp., 21 E. 40th St.

GALLOWAY, Lee (A'23), Dir., Ronald Press Co., 15 E. 26th St.

GANNON, Thos. J. ('13), M. E., Dept. of Sanitation, City of New York, Rm. 808, 125 Worth St.

GARDEN, Nelson B. ('26; '33), 51 E. 42nd St.

GARDNER, Lester D. (A'22), 251 W. 101st St.

GARDNER, L. Robinson (J'29), Designing Engr., Gen. Devel. Co., 61 Broadway, New York, N. Y.; *for mail,* 89 Osborne Ave., Bay Head, N. J.

GARGER, John H., Jr. (J'36), Engrg. Asst., Test Dept., N. Y. Edison Co., Inc., 14th St. & East River.

GARRETSON, Francis M. ('26), Sales Serv. Engr., Westinghouse Elec. & Mfg. Co., 460 W. 34th St., New York, N. Y.; *for mail,* 40 Watson Ave., E. Orange, N. J.

GARRISON, Wyckoff L. ('16; '24), Asst. Mgr., Loco Dept., Ingersoll-Rand Co., 11 Broadway, New York, N. Y.; *for mail,* 612 Embree Crescent, Westfield, N. J.

GARSON, Thorvald N. ('18), Sales Engr., Bergen Point Iron Wks., Bayonne, N. J.; *for mail,* Rm. 329, 30 Church St., New York, N. Y.

GASKIN, Geo. H. ('22), Supt. Engr., Cunard White Star Line, 25 Broadway, New York, N. Y.; *for mail,* 146 Irving Ave., S. Orange, N. J.

GATELY, Wm. A. ('12; '19; '22), Exec. Dir., Hospital Bur. of Stands. & Supplies, Inc., 9 E. 40th St.

GATES, R. M. ('18; F'36), Manager, '28-31; Vice-President, '31-'33; V. P., Industrial Dept., Superheater Co., 60 E. 42nd St.; V. P., Charge Sales, Combustion Engrg. Co., Inc., 200 Madison Ave. (*former address for mail*).

ATJE, Frederick C. ('20; '23; '35), Sales Engr., Simler & Sengstaken, Inc., 271 Madison Ave., New York; *for mail,* 824 E. 22nd St., Brooklyn.

AVIT, Walter P. ('28), Power & Indus. Engr., F. H. McGraw & Co., 51 E. 42nd St.

AYLORD, Laurence T. ('24), V. P., Atlantic Gulf & Pac. Co., 15 Park Row, New York, N. Y.; *for mail,* 50 Bradford Ave., Upper Montclair, N. J.

EE, Warren H. (J'31), Coordinator of Teletype Installations, Am. Tel. & Tel. Co., 32—6th Ave., New York; *for mail,* 3047 Hobart St., Woodside, L. I.

EENENS, Leo ('24), E. E., N. Y. C. Tunnel Authority, 200 Madison Ave.; *for mail,* 110 Morningside Dr.

EFVERT, Chas. J. ('23), Safety Supvr., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.

EORGE, Leonard B. ('25; '35), Mar. Dept., Socony-Vacuum Oil Co., Inc., 26 Broadway, New York; *for mail,* 30 Columbus Pl., Westerleigh, S. I.

ERHARD, Hans W. ('24; '35), Sketchman, Engrg. Acctg. Dept., Washburn Wire Co., Inc., Foot of E. 117th St. & East River, New York; *for mail,* 8769—109th St., Richmond Hill, L. I.

ERSHBERG, Jos. ('32), Ch. Testing Engr., N. Y. Edison Co., Inc., E. 134th St. & Locust Ave.

IAUQUE, Robt. E. (J'36), Jr. Draftsman, Eagle Pencil Co., 710 E. 14th St.; *for mail,* 2349 Davidson Ave.

IBBS, Geo. ('90), Partner, Gibbs & Hill, Cons. Engrs., Pa. R. R. Sta.

IBSON, Geo. (J'31), C. H. Leach Co., 11 Park Pl., New York, N. Y.; *for mail,* 70 Oakwood Ave., Upper Montclair, N. J.

GIBSON, Geo. H. ('00; '07; '14), Senior Partner, Geo. H. Gibson Co., 100 Gold St., New York, N. Y.; *for mail,* 70 Oakwood Ave., Upper Montclair, N. J.

GIBSON, Robt. F. (J'32), Ch. Engr., Parkal Holding Corp., 23 W. 73rd St.

GILBERT, Kermit C. (J'31), Engrg. Asst., Hell Gate Power Sta., Test Div., N. Y. Edison Co., Inc., 134th St. & Locust Ave.

GILLROY, Bernard J. ('29), Cons. Engr., 101 Park Ave.

GILMORE, John W. ('27), Research Engr., Fidelity & Casualty Co. of N. Y., 80 Maiden Lane; *for mail,* 306 W. 94th St.

GITZENDANNER, Fred A., Jr. (J'34), Asst. to Mgr., Engrg. Dept., Dorr Co., Inc., 570 Lexington Ave., New York, N. Y.; *for mail,* 46 N. Arlington Ave., E. Orange, N. J.

GLAS, Ernest F. (J'31), 576 E. 137th St.

GLASS, Wm. C. ('12; '19), Dist. Mgr., U. P. M., Kidder Press Co., Inc., Rm. 3119, 135 E. 42nd St.

GLOSS, Eric A. (J'27), Indus. Engr., Eugene Szepesi, Inc., 103 Park Ave., New York; *for mail,* 3706—72nd St., Jackson Heights, L. I.

GLOYER, Walter (J'31), Calculator, M. W. Kellogg Co., 225 Broadway, New York; *for mail,* 216-62—114th Ave., St. Albans, L. I.

GOETZE, Fred'k A. ('95; '00), Treas., Columbia Univ., 76 William St.

GOLDMAN, Francis D. (J'34), Supervisor, Rate Engrg. Div., Westchester Ltg. Co., 9 S. 1st Ave., Mt. Vernon; *for mail,* 2160 Anthony Ave., New York.

GOLDSCHMIDT, Otto E. ('12), Cons. Engr., 22 E. 40th St.

GORDON, Geo. Wm. ('28), V. P., Stand. Oil Co. of Cuba, 26 Broadway, New York; *for mail,* Ardsley-on-Hudson.

GORDON, Ralph T. ('26), N. Y. Dist. Sales Mgr., Dean Bros. Co., 92 Liberty St.

GORDON, Seymour (J'33), 2440 Amsterdam Ave.

GORTON, Chas. E. ('15; F'36), Manager, '25-'28; Vice-President, '28-'30; Chairman, Admin. Council, Am. Uniform Boiler Law Soc., 95 Liberty St.

GOSS, Robt. J. (J'35), Draftsman, Permutit Co., 330 W. 42nd St.; *for mail,* 923 Walton Ave.

GOTTLIEB, Edw. ('21; '27; '35), Pat. Atty., 80 Wall St.

GOULD, Gerald B. ('31), Pres., Fuel Engrg. Co. of N. Y., 116 E. 18th St.

GRAF, Albert J. ('35), Gen. Wks. Mgr., R. Hoe & Co., Inc., 910 E. 138th St., New York, N. Y.; *for mail,* 238 Grove St., Westfield, N. J.

GRAFF, Wesley M. ('23), Dir., Safety Engrg. Div., Natl. Bur. of Casualty & Surety Underwriters, 1 Park Ave.

GRAHAM, Malcolm, Jr. ('30; '35), Plant Supt., Prod. Engr., Stewart & McGuire, Inc., 72 Spring St., New York; *for mail,* 4 Elliott Rd., Great Neck, L. I.

GRANGER, Abbott D. ('15), Pres., A. D. Granger Co., 30 Vesey St.

GRANHOLM, John A., Jr. (J'35), 2263 Chatterton Ave.

GRANT, H. C., Jr. (J'23), 470 W. 159th St.

GRANT, Taylor B. ('23; '35), Supvr., Bell Tel. Labs., Inc.; *for mail,* 90 Morningside Dr.

GRAY, Fred'k R. ('22), Steam Supt., Westinghouse Elec. & Mfg. Co., 460 W. 34th St.

GRAY, H. Liggett ('16; '25; '35), Asst. Mgr., Oakite Products, Inc., 22 Thames St.

GRAY, Newenham A. ('30), Cons. Engr., 210 W. 71st St.

GREEN, Geo. C. (J'34), M. E., Asst. to Tech. Dir., Acheson Colloids Corp., 444 Madison Ave., New York, N. Y.; *for mail,* 1866 Hudson Blvd., Jersey City, N. J.

GREENALL, Chas. H. (J'22), Supvr., Charge Metallic Matls., Bell Tel. Labs., Inc., 463 West St., New York; *for mail,* 67 Hillcrest Ave., Chatsworth Heights, Larchmont.

GREENBERG, Sidney (J'34), 56 E. 184th St.

GREENE, Geo. F. ('17; '19; '35), Engr., Supt. of Constr., Combustion Engrg. Co., Inc., 200 Madison Ave., New York; *for mail,* 116 Booth St., Hempstead, L. I.

GREENE, R. deC. ('35), Asst. Ch. Engr., Am. Cyanamid & Chem. Corp., 30 Rockefeller Plaza; *for mail,* 130 E. 39th St.

GREENE, Thos. Wm. ('27), Devel. Engr., Linde Air Products Co., 30 E. 42nd St.

GREENFIELD, Benj. S. ('30), Mech. Design & Specification Engr., Dept. of Docks, City of N. Y., Pier A, North River, New York; *for mail,* 1325 Union St., Brooklyn.

GREENWOOD, Heman ('18; '25; '35), V. P., International Gen. Elec. Co., 570 Lexington Ave.

GREIST, Alva O. ('17), Cons. Engr., 270 Madison Ave.

GRETHER, Edw. C. ('21), Equip. Engr., Am. Sugar Refining Co., 120 Wall St.

GREUL, W. Herman ('07), Cons. Engr., 32 W. 40th St.

GRIDLEY, Allen H. ('20; '30), Engr., Charge Design, H. S. Ferguson & Co., Cons. Engrs., 200—5th Ave.

GRIMISON, E. Douglas (J'27), Analytical Engr., Babcock & Wilcox Co., 19 Rector St.

GRISWOLD, Fred'k, Jr. (A'23), Pat. Lawyer, Orton & Griswold, 233 Broadway.

GRISWOLD, Robt. G. ('22), Ch. Technologist, Cities Service Co., 60 Wall St.

GROB, John J. ('19; '25), Engr. of Tests, N. Y. Edison Co., Inc., 134th St. & Locust Ave.

GROSSMAN, Louis ('26; '35; '35), Supt. Charge Prod., Eagle Pencil Co., 710 E. 14th St.; *for mail,* 420 W. 24th St.

GRUENBERG, Otto C. ('27; '32), Design Engr., Am. Loco. Co., 30 Church St., New York, N. Y.; *for mail,* 26 Kensington Terrace, Maplewood, N. J.

GRULICK, Francis K. ('21; '35), Office Mgr., Indus. Dept., Am. Arch Co., Inc., 60 E. 42nd St.

GUIGOU, Marc A. ('21), Asst. Engr., N. Y. Edison Co., Inc., 4 Irving Pl.

GUILLO, Harry P. ('12), Engrg. Dept., Gen. Printing Ink Corp., 15th Fl., 100—6th Ave.

GULICK, Henry ('15), Pres., Gulick-Henderson Co., 19 W. 44th St.

GULICK, Wilson M. (J'26), Sales Rep., Chas. L. Gulick Co., 110 E. 42nd St.

GUMAER, P. L. ('20; '27; '35), M. E., Tex. Co., Chrysler Bldg., New York; *for mail,* 90 Kent Ave., Hastings-on-Hudson.

GUNAGAN, Richard H. ('11), Engr., Fidelity & Casualty Co., 80 Maiden Lane, New York; *for mail,* 295 Washington Ave., Brooklyn.

GURIN, Herman M. (J'36), Tech. Asst., Air Conditioning Dept., Natl. Broadcasting Co., Inc., 30 Rockefeller Plaza; *for mail,* 1925 Crotona Ave.

GUSTAVSEN, Emil ('28; '32; '35), Asst. Engr., N. Y. Cent. R. R., 161st Power Sta., New York, N. Y.; *for mail,* 264—10th St., Hoboken, N. J.

GUTHER, Geo. W. (J'34), Draftsman, Dept. of Sanitation, Lafayette St., New York; *for mail,* 4740—41 St., Sunnyside, L. I.

HAAR, Selby ('12), Bur. Equip. & Opera., Rapid Transit Subway R. R., Bd. of Transportation, 250 Hudson St.; *for mail,* 25 W. 68th St.

HABEKOTTE, Geo. F. ('25; '35), Sales Engr., Johns-Manville Sales Corp., 292 Madison Ave., New York; *for mail,* Orchard Ridge Rd., Chappaqua.

HABER, Harold E., Jr. (J'32), 20 E. 20th St.

HAGAR, Arthur P. ('07; '12), Safety Car Htg. & Ltg. Co., 230 Park Ave.

HAGEMANN, Geo. E. ('14; '19; '24), Managing Editor, Alex. Hamilton Inst., 13 Astor Pl.

HAGEN, J. F. ('30), Mgr., Meritas Mills, 320 Broadway, New York; *for mail,* 40 Argyle Rd., Brooklyn.

HAGUE, Donald L. (J'35), Asst. to Adv. Mgr., Dorr Co., Inc., 570 Lexington Ave.; *for mail,* 465 W. 23rd St.

HAHN, Eugene ('29), Hahn Engrg. Co., 30 Church St.

HALL, A. Gage ('29; '35), Tech. Asst., M. E. Dept., Dorr Co., Inc., 570 Lexington Ave., New York; *for mail,* 24 West Dr., Douglaston, L. I.

HALL, Harry Y. ('24), Supt., Hell Gate Sta., N. Y. Edison Co., Inc., 134th St. & Locust Ave.

HALL, Robt. Everett ('98; '05), Sales Dept., Worthington Pump & Mchy. Corp., 2 Park Ave., New York, N. Y.; *for mail,* 1017 Madison Ave., Plainfield, N. J.

HALL, Wm. M. ('29; '35), Asst. Supt., Hell Gate Sta., N. Y. Edison Co., Inc., 134th St. & Locust Ave.

HALLOCK, E. F. ('31), Ch. Engr., Automotive Lubricants, Socony-Vacuum Oil Co., Inc., 26 Broadway.

HALPERIN, Wm. (J'36), 2851 Sedgwick Ave.

HALPERN, Benj. M. ('21; '26), Partner, Mgr., Gibson & Halpern, 15 Park Row.

HAMEL, Clarence G. (J'27), Asst. Research Engr., N. Y. Steam Corp., 130 E. 15th St., New York; *for mail,* 45 Hawthorne Pl., Manhasset, L. I.

HAMILTON, Wm. Edward ('24), Mgr., Constr. Dept., Sanderson & Porter, 52 William St.

HAMMARSTROM, Erik ('19), Pur. Engr., W. Va. Pulp & Paper Co., 230 Park Ave.

HAMMER, Edwin W. ('13), Mem. Firm, Hammer & Schwarz, 80 John St.

HAMMERS, Morgan J. ('14), Pres. & Gen. Mgr., Electrol, Inc., 441 Lexington Ave.

HAMMOND, Clarence Chas. ('32; '35), M. E., Charge Maint., Sheffield Farms Co., 524 W. 57th St.; *for mail,* 97 Arden St.

HAMMOND, Harry S. ('14; '35), Spec. Rep., Natl. Tube Co., 71 Broadway.

HAMMOND, John Stevens, Jr. (J'32), Sales Engr., Mercoid Corp., 90 West St.; *for mail,* 157 E. 81st St.

HAMPTON, Leon N. ('23; '35), Engrg., Supvr., Bell Tel. Labs., Inc., 463 West St.; *for mail,* 246 E. Tremont Ave.

HANASEK, Frank J. (J'28), Asst. Engr., Tenney & Ohmes, 101 Park Ave., New York; *for mail,* 7024—66th St., Glendale, L. I.

HANAUER, Sylvan L. ('25; '34; '35), Mgmt. Supervision, Gen. Realty & Utilities Corp., 285 Madison Ave.

HANLEY, Chas. D. (J'35), 956 Anderson Ave.

HANSEN, Anton ('14; '35), Gen. Mgr., Plants, Cent. Fdy. Co., 420 Lexington Ave., New York, N. Y.; *for mail,* 838 Clifton Ave., Newark, N. J.

HARAZIM, Stanley J. (J'27), Mem. Tech. Staff, Mech. Design, Bell Tel. Labs., Inc., 180 Varick St.

HARDGROVE, Ralph M. ('19; '25), Engr., Charge Design Dept., Babcock & Wilcox Co., 85 Liberty St.

HARDIN, Frank H. ('21), Pres., Assn. of Mfrs. of Chilled Car Wheels, Rm. 1556, 230 Park Ave.

HARDING, Adalbert (J'98), 100 Morningside Dr.

HARDING, Howard V. ('33), V. P., Peter Clark, Inc., 534 W. 30th St.; *for mail,* 180 Bennett Ave.

HARDY, Geo. F. ('95), Cons. Engr., 305 Broadway.

HARDY, John A. ('28; '33), Asst. Engr., Geo. F. Hardy, 305 Broadway.

HARDY, W. A. ('35), Engr., Charge Boiler & Mchy. Dept., Marsh & McLennan, Inc., 70 Pine St., New York; *for mail,* 12 Pryer Lane, Larchmont.

HARMAN, John J. ('06; '09; '12), Gen. Secy., Mfrs. Standardization Soc. of Valve & Fittings Industry, 420 Lexington Ave.

HARRIGAN, Wm. ('29), Automotive Engr., Tex. Co., 135 E. 42nd St., New York, N. Y.; *for mail,* 31 E. Newell Ave., Rutherford, N. J.

HARRINGTON, Earl W. ('19; '25), V. P., Charge N. Y. Office, Mfrs. Mutual Fire Ins. Co., 52 Vanderbilt Ave.

HARRISON, Gerald G. ('29; '35), Sales Engr., Powers Regulator Co., 231 E. 46th St., New York, N. Y.; *for mail,* 43 Parkview Dr., Millburn, N. J.

HART, Chas. F. ('14), Mech. Supt., New York Times, 229 W. 43rd St.

HARTER, I., Jr. ('08; '21), Babcock & Wilcox Co., 85 Liberty St.

HARTFORD, Ernest (A'18), Asst. Secy., A.S.M.E., 29 W. 39th St., New York; *for mail,* 28 Cliff Ave., Yonkers.

HARTWIG, Albert ('19; '35), N. Y. State Employment Serv., 124 E. 28th St.; *for mail,* 248 W. 105th St.

HARVEY, Wells F. (A'35), Business Mgr., American Weekly, 959—8th Ave.

HASKELL, Raymond ('28), Indus. Engr., Tex. Co., 135 E. 42nd St., New York, N. Y.; *for mail,* 49 Overlook Rd., Summit, N. J.

HATCH, Theo. F. ('35), Assoc. Dust Control Engr., Div. of Indus. Hygiene, N. Y. State Dept. of Labor, Rm. 332, 80 Centre St.

HATTON, Morton ('26; '33; '35), Power Rate Engr., Ebasco Services, Inc., 2 Rector St.

HAUCK, Edwin J. (J'31), Engr., Babcock & Wilcox Co., 19 Rector St.

HAUSEL, Walter M. ('18; '30), M. E., Ford, Bacon & Davis, Inc., 39 Broadway, New York; *for mail,* 68 Hamilton Ave., Yonkers.

HAUSMAN, Moses ('28; '34; '35), Treas., Muller & Hausman, 76 E. 11th St.; *for mail,* 447 Ft. Washington Ave.

HAUSWIRTH, W. G. (J'34), Jr. Engr., Equip. Div., Am. Can Co., N. Y. Central Bldg., 230 Park Ave.; *for mail,* 22 E. 47th St.

HAVEMEYER, Henry O., Jr. (J'30), Asst. to Pres., Brooklyn East. Dist. Terminal, 25 Broadway.

HAWKINS, Geo. W. ('13), V. P., Cities Serv. Oil Co., 11th Fl., 60 Wall Tower.

HAY, Wm. O., Jr. ('19; '35), V. P., Charge Reports & Analysis, Elec. Securities Corp., 570 Lexington Ave.

HAYS, John C. ('13), V. P., Stone & Webster Engrg. Corp., 90 Broad St.

HAYWARD, Judson ('15; '26), Secy., Hayward Co., 50 Church St.

HEAD, Francis ('06), Cons. Engr., 129 E. 10th St.

HEALEY, Edw. A. ('27; '32; '35), Designer Mch. Equip., Am. Cyanamid Co., 30 Rockefeller Plaza, New York; *for mail,* 407 Melbourne Ave., Mamaroneck.

HECK, Robt. C. H., Jr. (J'26), Estimator, Sales, Export, Natl. Supply Corp., 30 Rockefeller Plaza.

HECKER, A. E. ('21; '29), Cons. Engr., Chem. Constr. Corp., 30 Rockefeller Plaza.

HECKMAN, Jas. C. ('20), Engr., Stevenson, Jordan & Harrison, 19 W. 44th St., New York; *for mail,* 8 Bayard St., Larchmont.

HEIDERSBACH, Fritz (J'32), Designer & Checker, M. W. Kellogg Co., 225 Broadway, New York; *for mail,* 296 Nichols Ave., Brooklyn.

HEIMBERGER, Oscar W. ('23; '31), Engr., Griscom-Russell Co., 285 Madison Ave.

HEINEN, Fred C. (J'21), Camel Sales Co., 500—5th Ave.

HEINZE, Wm. August (J'30), Sales Engr., Ingersoll-Rand, 11 Broadway.

HELLER, Lewis W. ('18; '23; '35), Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail,* 111 Harrison St., E. Orange, N. J.

HELMER, Richard Louis (J'36), Inspr., Fidelity & Casualty Ins. Co., 80 Maiden Lane, New York, N. Y.; *for mail,* 2-37 Hartley Pl., Warren Point, N. J.

HEM, Elif S. (J'19), Serv. Engr., Allis-Chalmers Mfg. Co., 50 Church St., New York; *for mail,* 702—45th St., Brooklyn.

HENDERSON, Douglas ('31), V. P., Fuel Engrg. Co. of N. Y., 116 E. 18th St.

HENOFER, John P. ('20), Asst. Engr., Phœnix Engrg. Corp., 2 Rector St., New York, N. Y.; *for mail,* 104 Wood St., Rutherford, N. J.

HENRICKSEN, Bjarne ('26; '35), Ch. E. E., Sedgwick Mch. Wks., Inc., 150 W. 15th St., New York, N. Y.; *for mail,* 834—32nd St., N. Bergen, N. J.

HENRY, Alex S., Jr. ('16; '25; '35), Estimator, Brunswick-Kroeschell Co., 203 Fulton St.; *for mail,* 300 Central Park West.

HENRY, Wm. M. (J'17), Ch. Operator, Waterside Stas., N. Y. Edison Co., Inc., 666—1st Ave.; *for mail,* 300 Central Park West.

HENSE, John A. (A'19), East. Rep., No. Pump Co., Rm. 3818, Chrysler Bldg., 135 E. 42nd St.

HENSHAW, Fred'k V. ('00), 20 Pine St.

HENZE, Otto C. W. ('36), Apt. 1B, 255 W. 91st St.

HEPPENHEIMER, Herman (J'34), Draftsman, Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.; *for mail,* 46 Chaffee Ave.

HERB, Chas. O. ('28; '35), Assoc. Editor, Machinery, Indus. Press, 148 Lafayette St.

HERBERT, Fred'k D. ('99; '07), Pres., Kearfott Engrg. Co., Inc., 117 Liberty St.

HERLINGER, Louis F. (J'28), Instr. Elec. Physics & Math., R. C. A. Institutes, Inc., 75 Varick St.; *for mail,* 686 W. 204th St.

HERNON, Jos. L. ('17; '35), V. P., Brown, Wheelock, Harris Vought Co., Inc., 63 Wall St., New York; *for mail,* 3440 Bedford Ave., Brooklyn.

HERSCHMANN, Arthur J. ('00; '05), U. S. A. Agent, Vitkovice Steel Wks., 50 Church St.

HERTSLET, Victor B. (J'34), Field Mechanic & Engr., Merritt-Chapman & Scott Corp., 17 Battery Pl., New York; *for mail,* 43-05—47th St., Long Island City.

HESS, John S. ('27), Ch. Engr., Refineries, Sinclair Refining Co., 630—5th Ave.

HESSE, Otto H. (J'20), Real Estate Mgmt., Nehring Bros., Inc., 1441 St. Nicholas Ave., New York; *for mail,* 317 Bronxville Rd., Bronxville.

HEUMANN, John P. ('32; '35), 204—9th Ave.

HEWITT, Edw. R. ('13), Cons. Engr., Mack Trucks Co., Anable Ave., Long Island City; *for mail,* 127 E. 21st St., New York.

HICKLING, Ewart G. (J'27), Engr., Linde Air Products Co., 30 E. 42d St., New York; *for mail,* 59 Fenimore Rd., Mamaroneck.

HICKS, Kenneth M. (J'24), Plant Engr., Bell Tel. Labs., Inc., 395 Hudson St., New York; *for mail,* 90-21—188th St., Hollis, L. I.

HIGGINS, Theo. J. ('22; '27; '35), Leading Draftsman, Charge Mech. Design, N. Y. Edison Co., Inc., 4 Irving Pl., New York, N. Y.; *for mail,* 184 Jefferson Ave., N. Plainfield, N. J.

HIGGINS, Wm. J. (J'31), 1929 Broadway; *for mail,* 1028 Ogden Ave.

HILBERT, Chas. D. ('21; '35), M. E., Sherman Corp., 292 Madison Ave.; *for mail,* Hotel Elton, 4th Ave., cor. 26th St.

HILDEBRAND, H. Edw. ('20; '25; '35), Dir. Engrg., Bakeries Serv. Corp., 285 Madison Ave.

HILES, Elmer K. ('00; '06), Supt. Constr., Gulf Oil Corp., 17 Battery Pl.

HILL, Edgar G. ('21), V. P., Ford, Bacon & Davis, Inc., 39 Broadway.

HILL, E. Rowland ('07), Partner, Gibbs & Hill, Pa. Sta.

HILL, Myron F. ('32), Pres., Gerotor Licensing Co., 110 E. 42nd St.

HILLS, Frederic W. ('35), Cons., Mgmt., 551—5th Ave., New York, N. Y.; *for mail,* 165 Park Ave., E. Orange, N. J.

HILTON, B. LeRoy (J'36), Draftsman, Babcock & Wilcox, 19 Rector St.; *for mail,* 420 W. 118th St.

HINKEL, O. R. (J'33), Mch. Designer, R. Hoe & Co., Inc., 138th St. & East River; *for mail,* 12—5th Ave.

HIRSCHLAND, F. H. ('06; '16), Pres., Metal & Thermit Corp., 120 Broadway.

HOCH, Fred W. ('30; '35), Mgr., Prod. Mgmt. Dept., Fred W. Hoch Associates, Inc., 461—8th Ave.

HOCH, Walter A. (J'33), Apt. 23, 600 W. 150th St.

HODGKINSON, Francis ('02), Cons. M. E., 138 E. 36th St.

HOERNER, Jos. F. ('20; '27), Dist. Mgr., Baldwin Loco. Wks., 120 Broadway.

HOEVEL, H. F. ('21), 149 W. 75th St.

HOFFMAN, Herbert G. ('24; '35), M. E., Charge Maint., Continental Baking Co., 630—5th Ave., New York; *for mail,* 9 Franklin Ave., Yonkers.

HOFFMAN, John E. ('15; '22; '35), Cuban Am. Sugar Co., 136 Front St., New York; *for mail,* 32 Midchester Ave., White Plains.

HOFFMAN, Robt. J. ('20), V. P., Prest-O-Lite Co., Inc., 30 E. 42nd St.

HOFFMAN, Wm. H. (J'33), Project Engr., Combustion Engrg. Co., Inc., 200 Madison Ave.; *for mail,* 45 Prospect Towers, Tudor City.

HOGAN, John P. ('26), Mem. Firm, Parsons, Klapp, Brinkerhoff & Douglas, Engrs., 142 Maiden Lane.

HOGE, Wallace W. ('26; A'34), Investigator, Morgan Stanley & Co., Inc., 2 Wall St.; *for mail,* 1220 Park Ave.

HOLBROOK, Dio L. ('99), Engr., Retired, Otis Elev. Co., 260—11th Ave., New York, N. Y.; *for mail,* Lincoln Ave., Point Pleasant, N. J.

HOLBY, Worrell H. ('31), Pres., Ch. Engr., Boiler Rm. Equip., Inc., 9 E. 38th St.

HOLE, J. A. (J'27), Bell Tel. Labs., Inc., 463 West St., New York; *for mail,* 1017—72nd St., Brooklyn.

HOLLAND, C. Kenneth (J'36), M. E. Div., Phoenix Engrg. Corp., 2 Rector St., New York, N. Y.; *for mail,* 220 Westfield Ave., Elizabeth, N. J.

HOLLINS, Geo. G. ('21), Ch. M. E., J. G. White Engrg. Corp., 80 Broad St.

HOLLIS, Earl A. (J'24), Buyer, Bell Tel. Labs., Inc., 463 West St., New York; *for mail,* 3448—88th St., Jackson Heights, L. I.

HOLLOPETER, E. (J'31), Asst. Ch. Draftsman. Elec. Research Products, Inc., 250 W. 57th St.; *for mail,* 214 W. 96th St.

HOLLY, Ludwig F. ('25), Pres. & Gen. Mgr., Holly Pneumatic Systems, Inc., 15 E. 40th St., New York, N. Y.; *for mail,* 173 Ridgedale Ave., Madison, N. J.

HOLM, Sigurd S. ('24; '30; '35), United Elec. Light & Power Co., 4 Irving Pl.

HOPF, Adolph R., Jr. (J'29), Cons. Indus. Engr., Stevenson, Jordan & Harrison, 19 W. 44th St., New York, N. Y.; *for mail,* 3450 Boulevard, Jersey City, N. J.

HOPF, Harry A. ('18; '30), Managing Partner, Hopf, Kent, Willard & Co., 500—5th Ave.

HOPSON, Wm. H. ('24; '35), Hopson & Denihan, Inc., 103 Park Ave.

HORBUND, Isadore (J'36), Foreman, M. E. in Charge Maint., Natl. N. Y. Packing & Shipping Co., 327 W. 36th St.; *for mail,* 146 W. 170th St.

HORMANN, Frank R. (J'28), Ch. Engr., Ertel Engrg. Co., 120 E. 16th St.

HORN, Norman E. ('16; '25), Gen. Supt., Wellington Sears Co., 65 Worth St.

HORNE, Geo. Augustus ('19), V. P. & Ch. Engr., Merchants Refrig. Co., 17 Varick St.

HORNE, Jos. A. ('13), V. P., Charge Mfr., Yale & Towne Mfg. Co., 405 Lexington Ave.

HORNER, Edw. A. (J'35), Engrg. Asst., Power Plant Testing, N. Y. Edison Co., Inc., 4 Irving Pl., New York, N. Y.; *for mail,* 792 Edna Pl., N. Bergen, N. J.

HORTON, Albert J. ('22), Cons. Engr., R. Hoe & Co., Inc., 901 E. 138th St., New York; *for mail,* 103 Grandview Ave., White Plains.

HOSFORD, Wm. F. ('15), V. P., West. Elec. Co., Inc., Rm. 1400, 195 Broadway.

HOSSACK, Archibald B. ('14; '29), Am. Appraisal Co., 1 Cedar St.

HOTCHKISS, C. H. B. ('23; '26; '35), Editor. Heating & Ventilating, Industrial Press, 148 Lafayette St., New York, N. Y.; *for mail,* 151 Sheridan Ave., Hohokus, N. J.

HOUGH, David L. ('91; '92), 140 E. 40th St.

HOUGH, Wallace F. (J'30), Tech. Div., Engrg. Dept., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail,* 14 Lincoln Pkwy., Bayonne, N. J.

HOUGHTON, Chas. E. ('99), Assoc. Prof. M. E., N. Y. Univ., University Heights.

HOUSLEY, Thos. P. ('21; '23; '35), Otis Elevator Co., 260—11th Ave., New York, N. Y.; *for mail,* 503 Sherman Ave., Roselle Park, N. J.

HOUSUM, Chenoweth (A'08), M. E., Lummus Co., 50 Church St., New York, N. Y.; *for mail,* 1792 Watchung Ave., Plainfield, N. J.

HOVEY, Otis E. ('13), Cons. Engr., 71 Broadway.

HOWELL, Frank B. ('01), Tech. Adviser, Am. Radiator Co., 40 W. 40th St.

HOWELL, Henry Wilson, Jr. (J'26), V. P., Charge Maint., Cushman & Wakefield, Inc., 30 E. 42nd St.; *for mail,* 235 W. 75th St.

HOWES, Robt. V. ('21), Rating Engr., Consltd. Edison Co. of N. Y., Inc., 130 E. 15th St.

HUBBELL, J. E. ('23), Pat. Lawyer, 8 W. 40th St.

HUBBY, Paul E. (J'27), Safety Engr., Aetna Ins. Co., 100 William St.; *for mail,* Apt. 4H, 14[illegible] E. 52nd St.

HUCK, Wm. F. ('30; '35), Designing Engr., R. Hoe & Co., Inc., 138th St. & East River, New York; *for mail*, 8926—120th St., Richmond Hill, L. I.
HUDSON, Albert H. (A'17), Sales Agent, Am. Car & Fdy. Co., 30 Church St., New York, N. Y.; *for mail*, 57 Beverly Rd., Upper Montclair, N. J.
HUDSON, Darwin S. ('15), Asst. Engr., Maint. & Constr., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.
HUEBNER, Wm. C. (A'29), Owner, Huebner Labs., 202 E. 44th St.
HUGHES, Andrew M. (J'29), Guaranty Co. of N. Y., 31 Nassau St., New York, N. Y.; *for mail*, Edgewater Park, Burlington Co., N. J.
HUGHES, Henry E. ('16), Valuation Engr., Sanderson & Porter, 52 William St.
HUGHES, Robt. H. (J'26), Contract Engr., Oil Div., Foster Wheeler Corp., 165 Broadway, New York, N. Y.; *for mail*, 32 Claridge Court, Glen Ridge, N. J.
HULST, John ('18), V. P., U. S. Steel Corp., Rm. 1901, 71 Broadway.
HUMMEL, Ragnar A. ('22), Exec. V. P., Lone Star Cement Corp., 342 Madison Ave.
HUMPHREYS, Cyril G. ('32; '35), Engrg. Asst., Opera. Dept., N. Y. Edison Co., Inc., 4 Irving Pl.
HUNTER, Jas. F. ('99; '09), Engr., Maint. & Constr., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.
HUNTING, Irving A. ('30), Designer, R. Hoe & Co., Inc., 138th St. & East River, New York, N. Y.; *for mail*, 1019 Clinton Ave., Plainfield, N. J.
HUPFEL, Adolph G. ('16), Treas., J. Chr. G. Hupfel Co., Inc., 229 E. 38th St.
HUTCHINGS, Clifford F. ('07; '13), Sales Dept., Shepard Niles Crane & Hoist Corp., 111 Broadway, New York, N. Y.; *for mail*, 105 Stanmore Pl., Westfield, N. J.
HUTCHINSON, Cary T. ('94), University Club, 1 W. 54th St.
HUTCHINSON, Ely C. ('12; F'36), Manager, '28-'31; Vice-President, '33-35; Mgr., Process Div., Alco Products, Inc., 30 Church St.
HUTCHINSON, J. B. ('31), Asst. Dist. Sales Mgr., Gulf Refining Co., Rm. 1519, 17 Battery Pl.
HUTCHISON, Miller R. ('12), Propr., Hutchison Lab., 180 W. 59th St., Box 1703.
HUVANE, Jas. F. ('24; '25; '35), Mgr., Compressor Sales, Chicago Pneumatic Tool Co., 6 E. 44th St.
HUY, Geo. E. (J'33), Valuation Engr., Ford, Bacon & Davis, 39 Broadway; *for mail*, 1011 Washington Ave.
HYDE, Jas. P. ('28; '35), Engr., Loco. Dept., Ingersoll-Rand Co., 11 Broadway, New York, N. Y.; *for mail*, 214 Crescent Ave., Leonia, N. J.
HYMANS, F. ('12), M. & E. E., Otis Elev. Co., 11th Ave. & 26th St.
IAGER, Raymond F. (J'30), Engrg. Design, Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail*, 547 Park Ave., Scotch Plains, N. J.
IMBEMBO, Emil A. (J'32), Jr. Matl. Engr., Metal Lab., Navy Yard, Brooklyn; *for mail*, 390 E. 184th St., New York.
INGLEE, Clinton ('20), Pres., Gen. Mgr., Natl. Water Main Cleaning Co., 50 Church St.
INSLEE, Heber C. ('07), M. E., Babcock & Wilcox Co., 19 Rector St., New York, N. Y.; *for mail*, 106 No. Arlington Ave., E. Orange, N. J.
INTEMANN, Hermann K. (J'31), Sales Engr., Halowax Corp., 247 Park Ave.
IRWIN, Capt. Daniel B. ('25; '35), Engr., Charge Design, 36 Bethune St.
IRWIN, Paul L. (J'22), M. E., Klein & Saks, 52 William St., New York; *for mail*, 83-17—34th Ave., Jackson Heights, L. I.
ISAACS, Rufus P. (J'36), 365 West End Ave.
ISEMAN, John W. ('27), Rehabilitation Asst., N. Y. State Education Dept., 80 Centre St.; *for mail*, 1 University Pl.
ISHAM, Clarence A. (J'28), 804 W. 180th St.
IVES, Loyal T. (J'28), Editorial Staff, The Iron Age, 239 W. 39th St., New York, N. Y.; *for mail*, 169 College Ave., New Brunswick, N. J.
JACKSON, Albert A. ('21; '26; '35), Erecting Engr., Chicago Pneumatic Tool Co., 6 E. 44th St.; *for mail*, 310 E. 35th St.
JACKSON, Chas. A. ('11), Hydroelec. Engr., Stanley & Patterson, 150 Varick St., New York, N. Y.; *for mail*, 194 Godwin Ave., Ridgewood, N. J.
JACKSON, Geo. P. ('21; '35), Ch. Engr., Combustion Engrg. Co., Inc., 200 Madison Ave., New York; *for mail*, 3342 N. 21st St., Flushing, L. I.
JACKSON, Jas. B. ('31; '35), Estimator, Engrg. Dept., M. W. Kellogg Co., 225 Broadway; *for mail*, 250 W. 82nd St.
JACKSON, Col. John Price ('03), Personnel Dir., N. Y. Edison Co., Inc., 4 Irving Pl.
JACKSON, Wm. H. (J'36), Apprentice Engr., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail*, 42 N. College St., Carlisle, Pa.
JACOBUS, D. S. ('89; H'34), Manager, '00-'03; Vice-President, '03-'05; President, '16; Advisory Engr., Babcock & Wilcox Co., 85 Liberty St.
JACOBUS, Robt. F. ('07; '12), Engr. & Arch., Francisco & Jacobus, 511—5th Ave.
JACOBY, Henry E. ('16), M. E., 205 E. 42nd St.
JAMES, John (J'28), M. E., Am. Soc. Htg. & Vent. Engrs., 51 Madison Ave.
JAPPE, K. W. ('34), Engr., Economist, Emerson Engrs., 30 Rockefeller Plaza.
JAROS, Alfred L., Jr. ('22), Partner, Jaros, Baum & Bolles, 415 Lexington Ave.
JAWITZ, Sydney (J'36), Sales Engr., Elec. Hoist & Motor Co., 197 Centre St., New York; *for mail*, 33-44—98th St., Corona, L. I.
JENIK, Louis A. ('19; '21; '35), Engrg. Dept., N. Y. Tel. Co., 140 West St.
JENKINS, Harold B. ('13; '22; '35), M. E., Hegeman Harris Co., 360 Madison Ave., New York; *for mail*, 50 Virginia Rd., Douglaston, L. I.
JENKS, Frank (J'34), Training Course, Natl. Lead Co., 111 Broadway, New York; *for mail*, 1465 Dean St., Brooklyn.
JENNINGS, Wm. A. ('27; '35), Supt., Charge Constr., Rowland Tompkins, 420 Lexington Ave.; *for mail*, 526 W. 113th St.
JOBST, Fred'k J. (J'25), Spec. Sales Rep., Chicago Pneumatic Tool Co., 3655 Iron St., Chicago, Ill.; *for mail*, 6 E. 44th St., New York, N. Y.
JOHNSEN, Bjournulf ('22; '35), Partner, Goss-Johnsen, 71 Murray St.
JOHNSON, A. Pemberton (J'32), Personnel Asst., Vick Chem. Co., 122 E. 42 St., New York; *for mail*, 116 Sunnyside Dr., Yonkers.
JOHNSON, David C. ('07; '17), Pres., N. Y. Steam Corp., 4 Irving Pl.
JOHNSON, Francis E., Jr. ('16), V. P., M. W. Kellogg Co., 225 Broadway.
JOHNSON, Herbert W. ('22; '30), 56 E. 66th St.
JOHNSON, Herman H. ('26; '33; '35), Asst. Engr., Office of Ch. Oper. Engr., N. Y. Edison Co., Inc., 4 Irving Pl.; *for mail*, 120 Riverside Dr.
JOHNSON, Horace A. ('23; '30), Asst. to M. E., N. Y. Edison Co., Inc., 4 Irving Pl., New York, N. Y.; *for mail*, 123 Howland Ave., W. Englewood, N. J.
JOHNSON, Howard W. (J'32), 2251 Sedgwick Ave.
JOHNSON, Jas. W. ('17; '25), Pres., Johnson, Inc., 95 Liberty St.
JOHNSON, Martin M. ('22), Engr., Pressure Vessel Dept., M. W. Kellogg Co., 225 Broadway; *for mail*, 21 E. 80th St.
JOHNSON, Raymond D. ('11), Hyd. Engr., 67 Wall St.
JOHNSON, Robt. ('13), Treas., Dir., Master Rule Mfg. Co., Inc., 815 E. 136th St.; *for mail*, 4069 Seton Ave.
JOHNSON, Roy E. ('25; '28; '34), Vice-Pres., Gen. Mgr., Arenco Mch. Co., Inc., 25 W. 43rd St.
JOHNSON, Walter A. (J'35), Instr., Dept. M. E., Columbia Univ.
JOHNSTON, Leith ('34; '35), M. E., Charge Maint., Am. Totalisator Co., Inc., 745—5th Ave.
JOHNSTON, Wm. Stanley ('23; '26), Engr., Mech. Div., Phoenix Engrg. Corp., 2 Rector St., New York.; *for mail*, 15 Summit St., E. Orange, N. J.
JONES, Bassett ('32), Partner, Meyer, Strong & Jones, Inc., 101 Park Ave.
JONES, Russell C. ('12; '19), V. P., Griscom-Russell Co., 285 Madison Ave.
JONGE, A. E. Richard de ('27), M. E., Babcock & Wilcox Co., 85 Liberty St.
JORDAN, Wm. Allen ('03; '12), N. Y. Sales Mgr., Essex Wire Corp., 103 Park Ave.
JORY, Robt. ('26), Sales Engr., Riley Stoker Corp., 103 Park Ave.
JOY, Jos. ('17; '21; '35), Sales Engr., R. M. Barwise, Inc., 75 Varick St.
JOYCE, Capt. C. S. ('22), Engineers' Club, 32 W. 40th St.
JUCHTERN, C. D. ('28; '34; '35), Engr., Superheater Co., 60 E. 42nd St., New York; *for mail*, 1479 Bedford Ave., Brooklyn.
JUDE, Henry (J'16), Asst. Gen. Sales Mgr., Consltd. Ashcroft-Hancock Co., Inc., 135 E. 42nd St.
JUDSON, Cyrus Field ('17; '23), Asst. to Pres., Petroleum Heat & Power Co., 511—5th Ave., New York; *for mail*, Ardsley-on-Hudson.
KABILI, Murray M. (J'34), Pur. Charge Design, Typhoon Air Conditioning Co., 252 W. 26th St.
KADDELAND, Christian R. ('29), Ch. Engr., Harris Seybold-Potter Co., 461—8th Ave.
KAEMPFFERT, Waldemar ('30), Sci. & Engrg. Editor, New York Times, 10th Fl., 229 W. 43rd St.
KAHN, Herman (J'35), Consltd. Products Co., 15 Park Row.
KAHN, Leo ('29; '34; '35), Designer, Dorr Co., Inc., 247 Park Ave., New York, N. Y.; *for mail*, 894 Park Ave., N. Bergen, N. J.
KALEY, Geo. B. ('13; '23) Sales Rep., Pettibone Mulliken Co., 52 Broadway; *for mail*, 309 W. 86th St.
KALKHUIS, Fred W. (J'29), Apt. 5E, 345 E. 209th St.
KALMBACH, Fredk. ('28), Pres., Treas., Gen. Mch. Co., Inc., 820-26 E. 140th St.
KANTROW, Melville W. ('21; '35), M. E., Am. Safety Razor Corp., 303 Jay St., Brooklyn; *for mail*, 244 W. 72nd St., New York.
KARASSIK, Igor J. (J'35), Engr., Pump Appl. & Sales, Worthington Pump & Mchy. Corp., Harrison, N. J.; *for mail*, 218 W. 10th St., New York, N. Y.
KARELITZ, Geo. B. ('27), Prof. M. E., Columbia Univ.
KAREKIN, Y. M. ('26), Cons. Engr., 136 Liberty St.
KARLSON, Chas. B. ('22; '35), V. P., Sales Mgr., Seamless Steel Equip. Corp., 39 Broadway.
KASSANDER, A. R. ('36), Accountant, Lybrand, Ross Bros. & Montgomery, 90 Broad St.
KATCHER, Morris ('19; '30), Engr., Modern Engrg. Co., New York; *for mail*, 4322—47th St., Long Island City.
KATES, Edgar J. ('16; '21), Cons. Engr., Diesel Eng. Specialist, 415 Lexington Ave.
KATTELLE, Laurence W. ('36), Asst. to V. P. in Charge Engrg., Walworth Co., 60 E. 42nd St.
KATZENSTEIN, Martin L. ('03; '15), Pres., Warren Engrg. Corp., 117 Liberty St.
KAYAN, Carl F. (J'25), Instr., Dept. of M. E., Columbia Univ., 538 W. 120th St.
KAYSER, Wendell H. ('20; '28), Partner, W. H. Kayser & Co., 823 Empire State Bldg.
KEATING, Thos. E. ('14; '21), Asst. to V. P., Westinghouse Elec. & Mfg. Co., 150 Broadway.
KEEFE, Daniel C. ('19; '35), Gen. Sales Mgr., Ingersoll-Rand Co., 11 Broadway.
KEELER, J. F. (J'36), Sales Engr., Steel & Tubes, Inc., 78 Scott Ave., Brooklyn; *home address*, 151 E. 81st St., New York.
KEELEY, Wm. C., Jr. ('29), Asst. V. P., Air Reduction Co., Inc., 60 E. 42nd St.
KEENAN, Walter F., Jr. ('12; '25), V. P., Charge Engrg., Foster-Wheeler Corp., 165 Broadway.
KEENAN, Walter M. ('17; '28), Cons. Engr., 114 Liberty St.
KEESING, Maurice ('22; '35), Cons. Engr., 1549 Leland Ave.
KEHL, Robt. J. ('15; '23), Cons. Engr., Linde Air Products Co., 30 E. 42nd St.
KELLER, Allen Wm. ('21; '27; '35), Cons. Engr., 3415 Tibbett Ave.
KELLER, Edwin (J'31), Engr., Devel. & Exper. Wk., Anchor Cap & Closure Corp., 22 Queens St., Long Island City; *for mail*, 964 Anderson Ave., New York.
KELLER, Jos. F. ('08), Rm. 1611, 50 Broadway.
KELLOGG, Morris W. ('13), Pres., M. W. Kellogg Co., 225 Broadway.
KELLOGG, Raymond M. ('15), Asst. Engr., Mfg., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.
KELSEY, Geo. W. ('21; '30), Pres., G. W. Kelsey & Co., 101 Park Ave.
KEMMER, A. J. (J'31), M. E., Mch. Design, Dorr Co., Inc., 247 Park Ave., New York; *for mail*, 8769—94th St., Woodhaven, L. I.
KENDE, Geo. (J'32), Ch. Engr., Universal Camera Corp., 32 W. 23rd St.; *for mail*, Apt. 5A, 210—6th Ave.
KENNEDY, Harold T. (J'34), Drafting Plant Layout, A. R. Burnette, Cons. Engr., 50 Pine St.; *for mail*, 735 W. 172nd St.
KENNEDY, Jas. S. ('15), Asst. Engr. Constr., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.
KENNEDY, Wm. P. ('13), Pres., Kennedy Engrg. Corp., 1767 Broadway.
KENT, Frank J. ('28), Ramsey & Kent, 233 Broadway.
KENT, Robt. Willard ('17; '19; '24), Engrg. Partner, Charge Prod. Mgmt. Serv., Hopf, Kent, Willard & Co., 500—5th Ave.
KEOWEN, Robt. T. (J'32), Temperature Control, Metropolitan Life Ins. Co., 1 Madison Ave., New York, N. Y.; *for mail*, 80 Vanderburgh Ave., Rutherford, N. J.
KERBEY, E. A. ('30; '35), East. Mgr., Midwest Piping & Supply Co., Inc., 30 Church St.
KERINS, John S. ('12; '29), Asst. M. E., N. Y. Edison Co., Inc., 4 Irving Pl.
KERNER, Leo. C. ('28), V. P., Natl. Carloading Corp., 19 Rector St.
KERR, Howard J. ('18), Exec. Asst., Babcock & Wilcox Co, 85 Liberty St., New York, N. Y.; *for mail*, 269 Prospect St., Westfield, N. J.
KESSLER, Henry R. ('22; '26; '35), Republic Flow Meters Co., 101 Park Ave., New York, N. Y.; *for mail*, 6779 Dartmouth St., Forest Hills, L. I.

KEYS, Douglas L. ('19; '25), Lub. Engr., Tex. Co., 135 E. 42nd St., New York; *for mail*, 1966 Delamere Pl., Brooklyn.
KIDDE, Walter ('21), Pres., Walter Kidde & Co. & Walter Kidde Constructors, 140 Cedar St.
KIEHNLE, Wm. A. ('29; '35), Secy., Mem. Firm. Wm. V. Kiehnle Co., 3606 Park Ave.
KIESELBACH, Henry A. ('14; '29), Gen. Mgr., Insulation Dept., Johns-Manville Sales Corp., 22 E. 40th St., New York, N. Y.; *for mail*, 43 Myrtle Ave., Montclair, N. J.
KING, Dudley W. (J'34), Patent Dept., Holland & Armstrong, 2 Rector St.
KING, Fred'k J. ('27), Ch. Engr., Linde Air Products Co., 30 E. 42nd St.
KING, Geo. I. ('01), Designer, Bd. of Transportation, 49 Lafayette St., New York; *for mail*, 15 Stratford Rd., Brooklyn.
KING, Norman M. ('17; '22), Ch. Engr., Singer Sewing Mch. Co., 149 Broadway.
KITTREDGE, John W. ('16; '35), 353 E. 56th St.
KITTREDGE, Severn W. (J'30), Sales Engr., Hookless Fastener Co., 71 W. 35th St.; *for mail*, 353 E. 56th St.
KLEES, Albert L. ('29), Combustion Utilities Corp., 60 Wall St.
KLEFFEL, Harrison E. ('23; '35), Harek Furnace Co., 580—5th Ave.; *for mail*, 215 W. 88th St.
KLEIN, Bernard A. ('24; '35), Shelton Hotel, 49th St. & Lexington Ave.
KLEINMAN, Oscar (J'34), Draftsman, Dept. of Parks; *for mail*, 66 W. Tremont Ave.
KLEMIN, Alex ('19; '31), Prof. Aero. Engrg., Daniel Guggenheim Sch. of Aero., N. Y. Univ., University Heights.
KLOTZ, Edgar L. (J'20), M. E., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail*, P. O. Box 411, 25 Gray Terrace, Fanwood, N. J.
KNAPP, Vernon W. ('33), Ch. Engr., Supt. Inspc. Dept., London Guarantee & Accident Co., Ltd., 55—5th Ave.
KNOEDLER, Elmer L., Jr. (J'34), Chem. Engr., Charge Gas Mask & Research, Davis Emergency Equip. Co., Inc., 55 Van Dam St.; *for mail*, 542 W. 112th St.
KOHLER, Anthony M. ('17; '23), Gen. Mgr., Refractories Div., Babcock & Wilcox Co., 85 Liberty St.
KOHLMANN, Gunter (J'33), Pres., Charge Sales. Am. M. A. N. Corp., 40 Rector St.
KONHEIM, Harvey S. ('32; '35), Secy., Viscosity Devices Corp., 1170 Broadway; *for mail*, 308 W. 104th St.
KOPECK, Wm. W. ('25; '35), M. E., Charge Maint., Gimbel Bros., Inc., 1275 Broadway; *for mail*, 2328 Turnbull Ave.
KOPER, Fred G. ('32), Ch. M. E., Stuart James & Cooke, Inc., 17 Battery Pl.
KOPF, Jos. L. ('31; '35), V. P., Charge Prod. & Devel., Jabez Burns & Sons, Inc., 11th Ave. & 43rd St.
KORFF, Fred H ('28), Pres., Exec., F. H. Korff & Co., Inc., 225 W. 34th St.
KORNFELD, Alfred E. (A'11), 124 W. 79th St.
KORTGARD, Fred'k H. ('19; '35), Asst. Ch. Engr., N. Y. Edison Co., Inc., 666—1st Ave., New York, N. Y.; *for mail*, 103 Chestnut St., Ridgewood, N. J.
KRAMER, Harold K. (J'24), Asst. Treas., Borden Co., 350 Madison Ave., New York; *for mail*, 27 Linford Rd., Great Neck, L. I.
KRAUS, Milton Nathaniel (J'36), Asst. Plant. Engr., Natl. Casket Co., 29-76 North. Blvd., Long Island City; *for mail*, 44 Buchanan Pl., New York.
KRAUSS, Arthur H. ('20; '23; '35), Mech. Plant Betterment Engr., Ebasco Services, Inc., 2 Rector St., New York, N. Y.; *for mail*, 254 Lenox Ave., S. Orange, N. J.
KREBS, Frank J. (J'28), Indus. Engr., U. S. Rubber Products. Inc., 1790 Broadway, New York, N. Y.; *for mail*, 114 Fairview Ave., Bogota. N. J.
KREISINGER, Henry ('12), Engr., Charge Research & Development, Combustion Engrg. Co., Inc., 200 Madison Ave.
KRIEG, Edwin H. ('25; '33), Engrg. Dept., Am. Gas & Elec. Co., 30 Church St., New York, N. Y.; *for mail*, 297 Highwood Ave., Ridgewood, N. J.
KRIEG, John L. ('29; '35), Engr., Charge Design, Alco Products, Inc., 220 E. 42nd St., New York; *for mail*, 9321—202nd St., Hollis, L. I.
KRIEGSHEIM, H. ('24), 200 W. 86th St.
KRINNER, Ludwig (J'32), 131 E. 83rd St.
KROES, Leonard C. (J'35), Division Engr., Sales & Design, Holland Furnace Co., Holland, Mich.; *for mail*, 111 E. 39th St., New York, N. Y.
KROLLE, Serge L. (J'34), Designing Engr. (Circulation), Babcock & Wilcox Co., 19 Rector St.
KROOSS, John (J'25), Engr., Victaulic Co. of Am., 26 Broadway
KROUPSKY, Vladimir (J'34), 220 E. 16th St.
KRUEGER, F. J. ('22; '35), Engrg. Mgr., Natl. Aniline & Chem. Co., Inc., 40 Rector St.
KRUGER, Stephen J. P. (J'34), Motive Oper. Dept. (Steam Generation Unit), Interborough Rapid Transit Co., 600 W. 59th St.; *for mail* 997 E. 172nd St.
KUHLEN, Fred'k ('16; '23; '35), College of City of N. Y., New York, N. Y.; *for mail*, 491 Main St., Hackensack, N. J.
KUHNOW, Bernhard F. L. ('22; '35), Devel. Engr., Teleregister Corp., 60 Hudson St., New York; *for mail*, 666 S. 7th Ave., Mount Vernon.
KUNZ, Wm. J. ('16; '19; '35), Mgr., Drafting. Combustion Engrg. Co., Inc., 200 Madison Ave., New York; *for mail*, 16 Pine Ave., Port Washington, L. I.
KUPPENHEIMER, John D. (J'32), Estimator, Combustion Engrg. Co., Inc., 200 Madison Ave.
KURGANOFF, A. (J'33), Tech. Adviser to Pres., Amtorg Trading Corp., 261—5th Ave.
KUSOLD, Chas. (J'26), Margon Corp., 233 Spring St., New York; *for mail*, 1821 Woodbine St., Ridgewood, Brooklyn.
LABOULAIS, Jean ('36), Engr., Kennedy Van Saun Mfg. & Engrg. Co., 2 Park Ave.; *for mail*, 313 E. 17th St.
LABOUNSKY, Nicholas (J'36), Engr. Asst. in Test Dept., Interborough Rapid Transit Co., 600 W. 59th St.; *for mail*, 604 W. 135th St.
LACAZETTE, A. A. ('16; '21; '35), Pres., Penola Inc., Rm. 2811, 26 Broadway.
LACHNICHT, Geo. H., Jr. (J'35), Plant Supt., Charge Opera., New York Fuel Corp., 171st St. & Harlem River; *for mail*, 1401 University Ave.
LA FETRA, Harry L. ('28), Salvage Engr., Charge Salvage Div., Dept. of Purchase, City of N. Y., Municipal Bldg.; *for mail*, 270 Riverside Dr.
LAMACHE, Andrew (J'35), 1149 Hoe Ave.
LAMB, Jos. Francis ('23; '28), M. E., Tex. Co., 135 E. 42nd St.; *for mail*, 1344 Nelson Ave.
LAMBERT, Jos. L. ('21; '26), Technology Club, 22 E. 38th St.
LAMBERT, Stanley M. ('19; '25), Engineers' Club, 32 W. 40th St.
LAMBERTI, Harold V. (J'36), 560 W. 165th St.
LANE, Robt. S. ('21; '23; '35), M. E., Pocahontas Fuel Co., Inc., 1 Broadway, New York, N. Y.; *for mail*, 9 Patton Pl., Upper Montclair, N. J.
LANG, Henry W. (J'26), Asst. Engr., N. Y. Tel. Co., 101 Willoughby St, Brooklyn; *for mail*, 3042 Bainbridge Ave., New York.
LANG, Rudolph Chas. ('29), Natl. Biscuit Co., 449 W. 14th St.
LANGWORTHY, Ross A. ('19), Ross A. Langworthy Co., Cons. Engrg. & Constr., 485 Madison Ave.
LANZISERA, Jos. C. ('26; '31; '35), M. E., Design Spec. Mchy., Atlantic Coast Fisheries, Inc., 307 Water St., New York; *for mail*, 193 Martense St., Brooklyn.
LAPPIN, Jos. ('21; '22; '35), Pres., Jos. Lappin, Inc., 1819 Broadway.
LAQUIDARA, A. K. (J'29), Asst. Engr., Lincoln Fire Proofing Co., 1087 E. Tremont Ave.; *for mail*, 1916 Barnes Ave.
LA RAUS, Julius (J'36), 4500 Broadway.
LARDNER, Henry A. ('01), V. P., J. G. White Engrg. Corp., 80 Broad St.
LAREW, J. Lee ('21; '35), Engr., Charge Toll Power Devel. Group, Bell Tel. Labs., Inc., 463 West St., New York, N. Y.; *for mail*, 835 Main St., S. Amboy, N. J.
LAROCCA, John A. ('19; '35), Lubrication Engr., Tex. Co., 135 E. 42nd St.; *for mail*, 975 Walton Ave.
LARSON, Clifford M. ('25), Supvr. Engr., Sinclair Refining Co., 630—5th Ave.
LASK, Fred'k ('13; '35), Advertising Mgr., A. S. M. E., 29 W. 39th St.; *for mail*, 230 Riverside Dr.
LASKER, Harold H. C. ('36), V. P., Gen. Mgr., Integral Steel Fabricating Co., 125 E. 41st St.
LASKO, Chas. (J'34), 122 W. 179th St.
LAUFFER, Wm. G. ('23; '28; '35), Engr., Sanderson & Porter, 52 William St., New York, N. Y.; *for mail*, 18 Linden Terrace, Leonia, N. J.
LAUMAN, H. E. ('29; '35), Gen. Mgr., C. W. Lauman & Co., 50 Church St.
LAUTERBACH, Geo. Edw. (J'29), M. E., N. Y. Cent. R. R., 466 Lexington Ave., New York, N. Y.; *for mail*, 130 Edgewater Ave., Cliffside Park, N. J.
LAWRENCE, Howard B. ('18; '26), Engr., Cities Serv. Co., 70 Pine St.
LAWRENCE, John H. ('11; '20; F'36), Manager, '24-'27; Vice-President, '27-'29; Engr. for Receiver, Interborough Rapid Transit Co., 165 Broadway.
LAWRENCE, Stillson F. ('23; '33; '35), Hotel Tudor, 304 E. 42nd St.
LAWRENCE, Wm. H. ('25), Ch. Operating Engr., N. Y. Edison Co., Inc., 4 Irving Pl.
LEACH, Chas. H. ('20; '25; '35), Pres., C. H. Leach Co., 117 Liberty St., New York, N. Y.; *for mail*, 213 E. 3d Ave., Roselle, N. J.
LEARY, Geo. ('16), Pres., Morris & Cummings Dredging Co., Inc., 44 Whitehall St.
LECHLER, Bruno C. ('18; '21), Mgr., Pat. Dept., Am. Mch. & Metals, Inc., 100—6th Ave.
LEDERER, Jerome ('24; '30; '35), Ch. Engr., Aero. Ins. Underwriters, 156 Williams St.
LEE, Frank H. ('36), Instr. Drafting, Columbia Univ., 117th & Broadway.
LEE, George W. (J'32), S. S. Magnolia, Socony-Vacuum Transportation Co., 26 Broadway.
LEE, Henry B. (J'34), Apt. 12, 3153 Broadway.
LE GETTE, Marvin A. ('24; '26; '35), Mgr., Childs Mech. Dept., 247 W. 16th St., New York; *for mail*, 38 Cisney Ave., Floral Park, L. I.
LEGGO, Wm. F. (A'17), Sales Engr., M. W. Kellogg Co., 225 Broadway.
LEITCH, Howard W. ('22), Assoc. Ch. Oper. Engr., N. Y. Edison Co., Inc., 4 Irving Pl.
LENAU, Henri B. ('22), Supvg. Constr. Engr. in Field, Socony-Vacuum Oil Co., Inc., 26 Broadway.
LENDEROTH, Arnold W. ('23), Pres. & Gen. Mgr., Consltd. Eng. Stop Co., 120 Liberty St.
LENZ, Edw. ('29), Mgr. Distribution Opera., N. Y. Steam Corp., 130 E. 15th St.
LEONARD, Chas. F. ('13), Cons. Engr., 220 Broadway.
LEONARD, Wm. M. (J'26), Asst. Supt., Appliance Maint. Div., Consltd. Edison Co. of N. Y., Inc., 408 E. 111th St.
LEOPOLDOFF, Anatole ('30; '35), Engr., Borough Pres. Richmond, St. George, S. I.; *for mail*, 552 W. 141st St., New York.
LEPAGE, Clifford B. ('13), Asst. Secy., A.S.M.E., 29 W. 39th St., New York; *for mail*, 145 Greenway South, Forest Hills, L. I.
LEUDEMANN, Albert V. ('22; '35), N. Y. Engr. & Rep., Mears, Kane & Ofeldt Co., 11 Park Pl.
LEVERT, Lee J. ('23; '30; '35), Economy Engr., N. Y. Edison Co., Inc., Rm. 14735, 4 Irving Pl.
LEVINE, David B. (J'33), 1340 Nelson Ave.
LEVINGER, David ('28), Engr. of Mfg., West. Elec. Co., Inc., 195 Broadway.
LEVY, Sydney (J'32), Equip. Engr., Charge Constr. Equip., Wks. Progress Admin., 2nd Corps Area, Bldg. B1, Governors Island; *for mail*, 165 Jerome St., Brooklyn.
LEWIS, Nathan E. ('19), Engr., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail*, 1210 Evergreen Ave., Plainfield, N. J.
LEWIS, Stanley A. (J'30), Gibbs & Hill, Penn. Sta., New York; *for mail*, 359 St. Johns Pl., Brooklyn.
LEWIS, Warren D. ('16; '21; '35), Ch. Engr., New Yorker Hotel Corp., 34th St. & 8th Ave., New York, N. Y.; *for mail*, 391 Grove St., Upper Montclair, N. J.
LIBBEY, Richard Henry ('13; '17), Colt's Patent Fire Arms Mfg. Co., 20 Vesey St., New York; *for mail*, 517 Franklin Ave., Nutley, N. J.
LICHTENSTEIN, Jos. ('26), M. E., Charge Design & Devel., Foster Wheeler Corp., 165 Broadway, New York; *for mail*, 52 Clark St., Brooklyn.
LIEBOWITZ, Benj. ('20; '25), 420 Riverside Dr.
LIENAU, A. Williams ('22; '29; '35), Contract Engr., Babcock & Wilcox Co., 85 Liberty St., New York; *for mail*, 9 Vandeventer Ave., Port Washington, L. I.
LIFVERGREN, Eric R. ('35; '35), Maint. Supvr., Adams & Co., Real Estate, Inc., 1107 Broadway, New York, N. Y.; *for mail*, 289 Ogden Ave., W. Englewood, N. J.
LIGHTOWLER, Geo. R. ('16; '19; '35), 315—5th Ave.
LIGON, Wm. D. ('33), M. & E. E., Charge Design & Constr., U. S. Navy, Rm. 812, 641 Washington St.
LINDQUIST, David L. ('21), Ch. Engr., Otis Elevator Co., 11th Ave. & 26th St., New York; *for mail*, Hartsdale.
LINK, Robt. L. ('28; '35), Foreman, Charge Maint., N. Y. Cent. R. R., 340 West St., New York; *for mail*, Apt. G4, 141 E. 21st St., Brooklyn.
LIPHSHITZ, Israel N. (J'34), Specification Writer, Engrg. Matls., Dept. of Purchase, City of N. Y., 480 Canal St., New York; *for mail*, 1408 Sterling Pl., Brooklyn.
LIPKE, Leopold H. ('19; '35), Owner, Lipke Tool Wks., 247 Centre St., New York, N. Y.; *for mail*, 91 Lindsley Ave., Newark, N. J.
LITCHFIELD, Norman ('23), Engrg. Mgr., Gibbs & Hill, Pa. Sta.
LITTLE, Harry ('30), Sales Engr., R. Hoe & Co., Inc., 138th St. & E. River, New York; *for mail*, 629 Milton Rd., Rye.
LIVINGSTON, Robert T. ('22; '35), Asst. Prof. Indus. Engrg. Columbia Univ.; Dir. Research, Long Island Lighting Co., 50 Church St.
LOCKWOOD, Marquis H. ('17), Pat. Atty. & Expt., 2 Rector St.
LODGE, Harrie M. (J'25), Rm. 704, 30 Church St., New York, N. Y.; *for mail*, 122 Valley View Rd., Ridgewood, N. J.

LOEB, Leo ('11; '21), Pres., Loeb & Shaw, Inc., 57 William St.
LOEFFLER, Alfred (J'30), Clerk, Cohn-Hall-Marx Co., 93 Franklin St.; *for mail*, 891 Dawson St.
LOEFFLER, Fritz ('24), Pres., Loefler, Inc., 8 W. 47th St.
LOEWY, Geo. J. ('14), Dir., Bur. Vocational Activities, Bd. of Education, 500 Park Ave.
LOFGREN, Kenneth E. ('36), Instr., Descriptive Geometry & Kinematics, Cooper Union Inst. of Tech., Cooper Sq.
LOMBARDI, Americus ('24; '35), Struc. Draftsman, Bd. Transportation, City of N. Y., 49 Lafayette St., New York; *for mail*, 169 Clinton St., Brooklyn.
LONGFELLOW, Henry C. ('32; '35), Jr. Engr., N. Y. Edison Co., Inc., 4 Irving Pl.
LOPPIN, Alex. J. ('18; '35), Engr., Engrg. Dept., Fidelity & Casualty Co. of N. Y., 80 Maiden Lane, New York; *for mail*, 403 Beach Ave., Mamaroneck.
LOSS, Isidor R. (J'24), Engr., Turbo Blower Dept., Ingersoll-Rand Co., 11 Broadway, New York, N. Y.; *for mail*, Rowayton Ave., Rowayton, Conn.
LOWE, H. Leland ('03; '14), Cons. Engr., Stone & Webster Engrg. Corp., 90 Broad St.
LOWENSTEIN, Herbert M. ('19; '25; '30), Contract Engr., Combustion Engrg. Co., Inc., 200 Madison Ave., New York; *for mail*, 75 Van Reipen St., Jersey City, N. J.
LOWMAN, Albert H. (A'30), Secy., Treas., Phoenix Specialty Mfg. Co., 155 Wooster St., New York; *for mail*, 60 Jarvis Pl., Lynbrook, L. I.
LOWRY, Geo. A. ('97; '23), Pres., Lowry & Grant, Inc., 79 E. 130th St.
LOYD, Albert E. ('31; '35), Sales Engr., Roots-Connersville Blower Corp., 24 State St., New York, N. Y.; *for mail*, 65 Washington Ave., Plainfield, N. J.
LUCAS, Jos. A. ('21), Ch. Draftsman, McGraw-Hill Publ. Co., Inc., 330 W. 42nd St., New York; *for mail*, 9137—111th St., Richmond Hill, L. I.
LUCE, Richard S. ('19; '35), Sales Engr., Double Seal Ring Corp., Bausman Packing Co., Rm. 1005, 15 Moore St., New York; *for mail*, 168—73d St., Brooklyn.
LUCKE, Chas. Edw. ('03; '08), Prof. M. E., Columbia Univ., Physics Bldg.
LUCKIE, Geo. O. ('28; '35), 350 Madison Ave., New York; *for mail*, 2334—83d St., Brooklyn.
LUDLOW, G. Richard ('21), Mgr., Engrg. Dept., Quality Bakers of Am., 381—4th Ave.
LUECKEL, Wm. J. ('28), Sales Engr., Dunning Lueckel Engrg. Co., 17 John St.
LUFKIN, Geo. S. (J'30), Metallizing Engrg. Co., Inc., 44 Whitehall St.
LUKENS, Alan N. ('31), Ch. Engr., Ry. Steel Spring Co., 30 Church St., New York, N. Y.; *for mail*, 132 Westfield Ave., Elizabeth, N. J.
LULL, Edw. E. (J'36), Fuel Sales Engr., Stand. Oil Co. of N. J., 26 Broadway.
LUND, Nels B. ('20; '31), Engr., Charge New Mch. Sec., Devel. Dept., Dorr Co., 247 Park Ave., New York; *for mail*, Seaford Manor, L. I.
LUNDBERG, Oscar F. ('21), Engr., Charge Design, Otis Elev. Co., 260—11th Ave.
LUNDQVIST, Arvid ('20; '35), Devel. Engr., Natl. Biscuit Co., 449 W. 14th St.; *for mail*, 33 Riverside Dr.
LUNDT, Ernest C. (J'26), Serv. Engr., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl., New York, N. Y.; *for mail*, 19 Smith St., Bloomfield, N. J.
LUNGHARD, Carl F. (J'30), Pur. Dept., Asiatic Petroleum Co., 39th Floor, 50 W. 50th St.
LUTZ, Geo. ('24; '35), V. P., Charge Design & Shop, Mantle & Co., 1907 Park Ave., New York; *for mail*, 64-41 Madison St., Ridgewood, Brooklyn.
LYDALL, Chas. H. ('30), Kings Crown Hotel, 420 W. 116th St.
LYLE, Ernest T. ('18), 52 Gramercy Park, N.
LYON, Percy S. ('15; '19; '30), Engr., Charge Sales, Cochrane Corp. Products, Turbine Equip. Co., 75 West St.
LYONS, Wm. T. (J'33), Asst. Engr., Am. Ice Co., 414 E. 53d St., New York; *for mail*, 228 Trenor Dr., New Rochelle.
LYTLE, Chas. W. ('16; '21; '23), Assoc. Prof. & Dir. Indus. Cooperation, N. Y. Univ., University Heights.
LYTLE, John E. (J'36), Job Engr., M. W. Kellogg Co., 225 Broadway.
MAAK, Chas. ('16; '35), Field Engr., Combustion Engrg. Co., Inc., 200 Madison Ave., New York, N. Y.; *for mail*, 390 New Brunswick Ave., Fords, N. J.
MACDONALD, Ronald G. (J'28), Secy., Treas., Tech. Assn. of Pulp & Paper Industry, 122 E. 42nd St.
MACELWEE, Roy S. ('27), Cons. Engr., 101 W. 58th St.
MACGOWAN, Jas. F. ('33), Asst. Engr., Shelton Hotel, 49th & Lexington Ave., New York; *for mail*, 1940 E. 28th St., Brooklyn.
MACINTYRE, H. D. ('29), Ch. Engr., Inspc. Div., U. S. Guarantee Co., 90 John St., New York, N. Y.; *for mail*, 245 Sanford Ave., N. Plainfield, N. J.
MACKAL, Henry H. (J'33), M. E. Asst. in Lab., John Edward Ogden Co., 147 Cedar St., New York, N. Y.; *for mail*, 92 Washington Ave., Hawthorne, N. J.
MACKENZIE, Kenneth G. (A'17), Asst. to V. P., Cons. Chemist, Tex. Co., 135 E. 42nd St.
MACVENN, Melville J. ('30; '35), Engr., Design & Constr., Sanitation Dept., City of New York, Rm. 915, 125 Worth St., New York; *for mail*, 1625 E. 35th St., Brooklyn.
MACWATTY, Frank L. (J'20), Engr., Asano Bussan Co., Rm. 801, 165 Broadway.
MACY, Ralph G. ('16; '19), Ch. Engr., Bd. of Publ. Utility Commrs., 1060 Broad St., Newark, N. J.; *for mail*, Engineers' Club, 32 W. 40th St., New York, N. Y.
MADEHEIM, Huxley ('27; '33; '35), Arms & Madeheim, Engrs., 1 E. 44th St.
MAGEE, Geo. H. ('21; '35), Engr., Design of Gas Wks., Long Island Ltg. Co., 50 Church St., New York, N. Y.; *for mail*, 239 Vreeland Ave., Nutley, N. J.
MAGGS, Alfred (J'35), 72 Vermilyea Ave.
MAGINNIS, Wm. S. ('27; '35), Sr. Engr., Mar. Inspc. & Survey, U. S. Shipping Bd., 45 Broadway.
MAGUIRE, Jeremiah D. ('11), Pres., Federation Bank & Trust Co., 461—8th Ave.
MAHONEY, Harold J. (J'28), Sales Engr., Micro-Westco, 90 West St., New York, N. Y.; *for mail*, 31 Harvard St., Montclair, N. J.
MAILLER, John P. ('19; '35), Ch. Engr., Northeast. Water & Elec. Serv. Corp., 57 William St., New York, N. Y.; *for mail*, 180 Main St., Madison, N. J.
MAINE, W. C. (J'36), Engrg. Dept., Va. Pulp & Paper Co., 230 Park Ave.
MALLINA, R. F. ('23; '27; '35), Research Engr., Bell Tel. Labs., Inc., 463 West St.
MANGINI, Francis A., Jr. (J'36), Jr. Prod. Engr., Beach-Russ Co., 544 Union Ave., Brooklyn; *for mail*, 3763 Olinville Ave., New York.
MANTIUS, Otto ('15), Cons. Engr., 111 Broadway.
MARBURG, Louis C. ('09), Secy., Treas., Marburg Bros., Inc., 90 West St.
MARCHANT, John H. ('36), Instr. M. E., Columbia Univ.
MARINO, Dominic A. (J'35), 755 E. 216th St.
MARKFELDER, Chas. F. ('24; '31), Engr., Fidelity & Casualty Co. of N. Y., 80 Maiden Lane, New York; *for mail*, 8039—88th Rd., Woodhaven, L. I.
MARKS, Harold M. (J'26), Secy., M. E., Charge Maint., Edgar Ellinger, Inc., 16 E. 52nd St.; *for mail*, 333 E. 53rd St.
MARSHALL, Ernest W. ('04), Partner, Marshall & Hawley, Pat. Lawyers, 19 W. 44th St.
MARTENSSON, Marten ('24; '35), Designer, Babcock & Wilcox Co., 19 Rector St., New York; *for mail*, 345 Bay Ridge Pkwy., Brooklyn.
MARTIN, Geo. W. ('11), Supvg. Engr., U. S. Realty & Improvement Co., 111 Broadway.
MARTIN, Harold Edw. ('29; '30), Sales Engr., Babcock & Wilcox Co., 85 Liberty St., New York; *for mail*, Lawrence Farms, Chappaqua.
MARTIN, Henry H., Jr. ('26; '34; '35), Fed. Power Comm., Old U. S. P. O. Bldg. (501), Broadway & Park Row, New York; *for mail*, Old Post Rd., Croton-on-Hudson.
MARTIN, John ('25), 22 W. 77th St.
MARTIN, Kingsley L. ('19), Pres., Engr. Co., 17 Battery Pl.
MARTINTO, Pedro (A'01), Pres., Pedro Martinto, Inc., 90 West St.
MARX, Erich (J'36), Sales Engr., Electro Machy. Corp., 30 Church St.
MASEK, Cyrill A. M. ('35), Designer, Air Reduction Co., Inc., 60 E. 42nd St., New York; *for mail*, Grand View, Nyack.
MASSA, Robt. F. ('04), Secy. & Treas., Mrs. Robt. Falconer Massa, Inc., 319 E. 44th St.
MASSON, Henry J. ('29), Prof. Chem. Engrg., N. Y. Univ., University Heights.
MATLOCK, Chauncey ('13), Cons. Engr., Rm. 622, 30 E. 42nd St.
MATTKE, Chas. F. (J'31), Engr., Charge Design, Bell Tel. Labs., Inc., 463 West St., New York; *for mail*, 70-46 Broadway, Jackson Heights, L. I.
MATTLAGE, Rudolph F. L. ('23; '30; '35), Sales Engr., H. B. Smith Co., 10 E. 41st St., New York; *for mail*, 12 Archer Rd., W. Hempstead, L. I.
MAUGER, David N. ('11; '20), Exec. Asst., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail*, 67 Hobart Ave., Summit, N. J.
MAY, Edwin M. ('16; '35), Mgr., N. Y. Office, S. F. Bowser & Co., Inc., Chrysler Bldg., 135 E. 42nd St.
MAY, Stephen C. ('25; '32; '35), Engr., Charge Natl. Accts., Iron Fireman Mfg. Co., 50 E. 42nd St.
MAYER, Fred ('29; '35; '35), c/o A. S. M. E., 29 W. 39th St.
McBRIDE, John J. ('17; '35), Engr., Car Constr., Am. Car & Fdy. Co., 30 Church St.
McCARTHY, Edmund ('28; '34; '35), Fuel Engr., Philadelphia & Reading Coal & Iron Co., 143 Liberty St.
McCARTHY, R. H. ('28; '35), Engr., Devel. Organization, West. Elec. Co., Inc., 195 Broadway.
McCLARITY, John T. ('26; '35), 656 W. 179th St.
McCREERY, J. Harold (J'10), V. P., Jas. McCreery Realty Corp., 112 W. 42nd St.
McCUNE, C. A. ('21; '29), Secy., Magnaflux Corp., 25 W. 43d St.
McDERMOTT, Chas. C. ('22; '31), Pres., McDermott Water Heaters, Inc., 1819 Broadway.
McDONALD, Donald ('20), Secy. & Gen. Supt., Am. Meter Co., Rm. 2925, Lincoln Bldg., 60 E. 42nd St.
McGRAW, Jas. H. ('26), Chmn. Bd., McGraw-Hill Publ. Co., Inc., 330 W. 42nd St.
McHALE, Walter L. ('29; '35), Engr., Charge Design, Geo. F. Hardy, 305 Broadway.
McINTIRE, Chas. V. ('17), Semet-Solvay Engrg. Corp., 40 Rector St.
McIVER, Alex. ('13), Westinghouse Elec. & Mfg. Co., 30 Rockefeller Plaza.
McKEE, Neal T. ('07; '12), Gen. Serv. Mgr., Superheater Co., 60 E. 42nd St., New York; *for mail*, 1 Return Bend, Bronxville.
McKEE, Waldo McC. ('27; '35), Sales Engr., M. W. Kellogg Co., 225 Broadway.
McKEOWN, John A. ('31), Mar. Supt., J. H. Winchester Co., Newtex S. S. Co., 17 Battery Pl., New York; *for mail*, 37 Tompkins Circle, Tompkinsville, S. I.
McKIEVER, Wm. H. ('00), Pres., Wm. H. McKiever, Inc., 247 W. 13th St.
McLAIN, R. H. ('21), Sales Engr., Gen. Elec. Co., 570 Lexington Ave.
McLEAN, Jas. S. ('26), Asst. M. E., Charge Design & Constr., J. J. White Engrg. Corp., 80 Broad St., New York, N. Y.; *for mail*, 102 Florida Ave., Beverly Hills, Alexandria, Va.
McMEIN, Ernest C. ('33; '35), Engr., Charge Design, Wm. Strauss, 29 E. 22nd St., New York; *for mail*, 31-44—36th St., Astoria, L. I.
McNALLY, Keenan J. ('20; '27; '35), Asst. to Mech. Supt., N. Y. Times Co., 229 W. 43d St.; *for mail*, 73 E. 236th St.
McQUILLAN, John ('17; '35), c/o A. S. M. E., 29 W. 39th St.
McWHOOD, Thorne W. (J'35), Jr. Indus. Mgmt. Engr., Babcock & Wilcox Co., 19 Rector St., New York; *for mail*, 840—70th St., Brooklyn.
MEDE, John J. (J'36), 225 E. 66th St.
MELENDY, Jesse G. ('15), Mfg. Dept., Gen. Chem. Co., 40 Rector St., New York; *for mail*, 56 Grove St., Tarrytown.
MENKIN, Leonidas ('24; '26; '35), 1863 Loring Pl.
MENZL, Leon ('21; '24), Cons. Engr., 129 Front St.
MERCIER, Harvey O. ('30), Natl. Biscuit Co., 449 W. 14th St., New York, N. Y.; *for mail*, 189 N. Oraton Pkwy., E. Orange, N. J.
MERCNER, R. O. ('36), Charge Design Engrg., Bell Tel. Labs., Inc., 463 West St.
MERKT, O. L. ('16), V. P. & Ch. Engr., Abbott, Merkt & Co., Inc., 10 E. 40th St.
MEROLA, Jas. C. (J'32), Supvg. Engr., Merola Bros., Inc., 2376—1st Ave.
MERRIFIELD, Wm. ('23), Rate Engr., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.
MERRING, Harry L. (J'34), Sr. Engr., Charge Concrete & Bituminous Matls., Matls. Inspc. & Testing Unit, Wks. Progress Admin., 70 Columbus Ave., New York; *for mail*, 21-11—38th St., Astoria, L. I.
MERRITT, Harold W. (J'21), Instr. Physics, Cooper Union Inst. of Tech., Cooper Sq.
MERVINE, Wm. G. ('24; '35), Am. Gas & Elec. Co., 30 Church St., New York, N. Y.; *for mail*, P. O. Box 127, Phœnixville, Pa.
MERZ, Robt. G. ('07; '13), Ch. Engr., Am. Process Co., 53 Park Pl., New York, N. Y.; *for mail*, 57—9th Ave., Newark, N. J.
METCALFE, Wm. K. (J'36), Draftsman, J. O. Ross Engrg. Corp., 350 Madison Ave.
MEYER, Henry C., Jr. ('94; '03), Pres., Meyer, Strong & Jones, Inc., 101 Park Ave.
MEYER, Henry C. E. ('21), Ch. Engr., Gibbs Bros., Inc., 1 Broadway.
MEYER, Robt. Maxwell (J'28), *Charles T. Main Award*, '28; Staff Engr., Floyd H. Rowland & Co., 36 W. 44th St., New York, N. Y.; *for mail*, 6 Moller St., Tenafly, N. J.
MEYERSON, Morris H. (J'29), Test Engr., Nathan Mfg. Co., 406 E. 106th St., New York, N. Y.; *for mail*, 172 Dewey St., Newark, N. J.

MICHEL, A. Eugene ('06; A'08), Prop., A. Eugene Michel & Staff, 132 W. 31st St., New York; *for mail*, 24 Douglaston Pkwy., Douglaston, L. I.
MIDDLETON, C. W. ('32), V. P., Babcock & Wilcox Co., 85 Liberty St.
MIDGLEY, Fred'k W. ('04; '14), Engr., Charge Design, Otis Elev. Co., 250—11th Ave., New York; *for mail*, 11 Saratoga Ave., Yonkers.
MIDGLEY, Fred'k W., Jr. (J'32), Clerk, Engrg. Application Div., Otis Elev. Co., 260—11th Ave., New York; *for mail*, 11 Saratoga Ave., Yonkers.
MIHLSTIN, Lester N. (J'33), Asst. Prod. Mgr., Franklin Mch. Products, Inc., 663 Broadway, New York; *for mail*, 315 Wilson Ave., Brooklyn.
MILES, Wm. T. (J'30), Engr., Mfrs. Mutual Fire Insurance Co., 52 Vanderbilt Ave., New York; *for mail*, 485 Gramatan Ave., Mt. Vernon.
MILLER, Albert R. ('29; '35), Home Office Engr., Fidelity & Casualty Co. of N. Y., 80 Maiden Lane, New York, N. Y.; *for mail*, 6 N. 21st St., E. Orange, N. J.
MILLER, Archibald T. (J'25), Engr., Research Dept., Barrett Co., 40 Rector St.; *for mail*, 250 Northern Ave.
MILLER, Arnold H. ('21; '24), Cons. Engr., 299 W. 12th St.
MILLER, Harry P., Jr. (J'33), Jr. Engr., W. Va. Pulp & Paper Co., 230 Park Ave., New York; *for mail*, 175 Steuben St., Brooklyn.
MILLER, John Andrew ('13), Pres., Penn. Dixie Cement Corp., 60 E. 42nd St.
MILLER, Robt. W. (J'36), Investment Analyst, Iron & Steel & Related Industries, Scudder, Stevens & Clark, 1 Wall St.
MILLER, Roswell ('22; '26; '35), V. P., Ladd & Nicholas, 4 E. 46th St.
MILLER, Spencer, Jr. ('22; '35), Secy., Workers Education Bur. of Am., 1440 Broadway.
MILLER, Wm. D. ('28; '35), Engr., Alco Products, Inc., 30 Church St., New York, N. Y.; *for mail*, 6 Walker Ave., Morristown, N. J.
MISCH, Chas. E. ('22; '30; '35), Dist. Mgr., Charge Engrg., Sales & Serv., Read Mchy. Co., Inc., of York, Pa., 60 E. 42nd St.; *for mail*, 310 W. 72nd St., New York, N. Y.
MITCHAM, E. Hartwell (J' 23), Partner, E. H. Mitcham & Co., Indus. Design & Engrg., c/o Howard Ketcham, Inc., 30 Rockefeller Plaza; *for mail*, 575 Park Ave.
MITCHELL, Albert E. ('91), Pres. & Treas., Wyckoff Pipe & Creosoting Co., 522—5th Ave.; *for mail*, Sherman Square Hotel.
MIXTER, Geo. W. ('99; '08), V. P., Day & Zimmermann, Inc., 165 Broadway.
MIYAKAWA, Tetsuo Scott (J'32), Indus. Engr., S. Manchuria Ry. Co., 2503 Lincoln Bldg., 60 E. 42nd St.; *for mail*, c/o Orson D. Munn, 24 W. 40th St.
MOEN, Leclanche ('17), Investment Banker, McClure, Jones & Co., 115 Broadway.
MOLONY, Noblett J. ('27), M. E., Charge Maint., Natl. Biscuit Co., 449 W. 14th St.; *for mail*, 4 E. 95th St.
MOLTER, Frank H. (A'22), 201 E. 40th St.
MONROE, F. Adair, Jr. ('16), Pres., Cuba Co., 441 Lexington Ave.
MONTGOMERY, Graham L. ('15; '22; '28), Managing Editor, Food Industries, 330 W. 42nd St., New York; *for mail*, 4 Ivy Way, Port Washington, L. I.
MONTGOMERY, Ora C. ('21), Asst. Supt. Power, N. Y. Cent. R. R. Co., Rm. 1842, Grand Central Terminal.
MOODY, V. D. ('16), Pres., Moody Engrg. Co., Inc., 90 West St.
MOONEY, Jas. D. ('19), Pres., Gen. Motors Export Co., 1775 Broadway.
MOORE, Daniel ('24; '32; '35), Supt. Constr., Hanbury Co., Inc., 156 E. 42nd St.; *for mail*, 569 E. 191st St.
MOORE, Henry H. ('27), Opera. Engr., East River Generating Sta., N. Y. Edison Co., Inc., 15th St. & Irving Pl.; *for mail*, 215 W. 23rd St.
MOORE, Wm. T. (J'27), Engrg. Design Dept., Babcock & Wilcox Co., 85 Liberty St.
MOOREHEAD, Dwight G. ('24; '27), Sales Engr., Newport News Shipbldg. & Dry Dock Co., 90 Broad St.
MORAN, Daniel E. ('86; '04), Sr. Partner, Moran & Proctor, Cons. Engrs., 120 E. 41st St.
MOREHEAD, F. Hugh ('19; '35), V. P., Charge Engrg., Walworth Co., 60 E. 42nd St.
MOREINIS, David ('22; '35), V. P., Charge East. Sales, Continental Mch. Specialties, Inc., 1301 Washington Ave., S., Minneapolis, Minn.; *for mail*, 1420 Noble Ave., New York, N. Y.
MORGAN, Albert H. ('18; '26; '35), Gen. Bldg. Supvr., West. Union Tel. Co., 60 Hudson St.; *for mail*, 2475 Palisade Ave.
MORGAN, Alva B. ('30; '34), Rate & Power Consultant, Edison Elec. Inst., 420 Lexington Ave., New York, N. Y.; *for mail*, Mansfield Ave., Darien, Conn.
MORGAN, Thos. A. ('29), Pres., Sperry Corp., 30 Rockefeller Plaza.
MORIN, Louis H. ('30), Engr. Charge Design, Gries Reproducer Corp., 463 E. 133d St.; *for mail*, 1560 Grand Concourse.
MORLEY, Marcus D. ('17; '23), Mgr., Serv. & Erection Dept., Combustion Engrg. Co., Inc., 200 Madison Ave.
MORRIS, W. Cullen ('14), V. P., Ch. Engr., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.
MORRISON, Wm. S. ('14), Asst. M. E., Charge Design, N. Y. Edison Co., Inc., 4 Irving Pl.
MORRISSEY, John P. ('24), Pres., John P. Morrissey Elec. Co., Inc., 405 Lexington Ave.
MORROW, L. C. ('16; '24), Editor, Factory Management & Maintenance, McGraw-Hill Publ. Co., Inc., 330 W. 42nd St.
MORROW, Robt. Lee ('22; '29), 465 W. 23d St.
MORTON, Quincy L. ('23; '35), Propr., Never Slip Safety Clamp Co., Grand Central Annex., P. O. Box 448; *for mail*, 422 E. 58th St.
MOSES, Asheleigh S. ('14), Rm. 1814, 111 Broadway.
MOSES, Fred C. ('18; '26), M. E., West. Elec. Co., Inc., 80 John St., New York, N. Y.; *for mail*, 197 Serpentine Rd., Tenafly, N. J.
MOSS, Herbert H. ('17; '35), Engr., Devel. Dept., Linde Air Products Co., 30 E. 42nd St.
MOTHERAL, Harry Haviland ('25; '35), Checker, Gibbs & Cox, Inc., 21 West St., New York, N. Y.; *for mail*, 33 Clinton Ave., Arlington, N. J.
MOULD, Arthur E. (A'21), Sales Engr., Indus. Div., Tide Water Oil Co., 17 Battery Pl., New York; *for mail*, P. O. Box 322, 11 Garrison Rd., Williamsville.
MOXHAM, Egbert ('06; '12), Partner, Shields & Co., 52 Wall St., New York; *for mail*, Great Neck, L. I.
MUCHNIC, Chas. M. ('27), 74 Trinity Pl.
MUDGE, Robt S. (J'35), Palo Myers, Inc., 81 Reade St., New York; *for mail*, 856 Park Pl., Brooklyn.
MUDGE, Sterling W. ('14; '20; '24), Asst. Gen. Mgr., Charge Sales, Socony-Vacuum Oil Co., Inc., 230 Park Ave.
MUELLER, Victor H. ('07; '21), Ch. Designing Engr., Cities Service Co., 60 Wall St.
MUHLFELD, John E. ('08), Cons. Engr., Transportation, 25 Broad St.; *for mail*, Hotel Chatham, 48th St. & Vanderbilt Ave.
MUHLSTEFF, Robt. P. (J'31), M. E., Bell Tel. Labs., Inc., 463 West St.; *for mail*, 100 W. 105th St.
MUIR, Jas. F. ('20), Power Engr., Am. Water Wks. & Elec. Co., 50 Broad St.
MUIR, Malcolm (A'29), Pres., McGraw-Hill Publ. Co., Inc., 330 W. 42nd St.
MULDAUR, Geo. B. ('20), Gen. Agt., Underwriters Lab., 111 Leonard St.
MULLER, Alfred (A'23), Pat. Atty., 52 Vanderbilt Ave.
MULLER, Daniel L. ('34; '34; '35), Boiler & Mchy. Dept., Marsh & McLennan, Inc., 70 Pine St.
MULLIGAN, Paul B. (J'35), Sales Engr., Lamson Co., 232 Madison Ave.
MULLIKIN H. F. (J'30), *Junior Award*, '36; Analytical Engr., Babcock & Wilcox Co., 85 Liberty St.; *for mail*, 86 Charles St.
MUMFORD, Albert R. ('19; '24; '27), Research Engr., Charge Engrg. Research Dept., N. Y. Steam Corp., 130 E. 15th St.
MUNIER, Leon L. ('21; '26), Pres., Treas., Wolff & Munier, Inc., 222 E. 41st St.
MURPHY, Benj. S. ('05; '16), Ch. Engr., East River Sta., N. Y. Edison Co., Inc., 801 E. 14th St., New York, N. Y.; *for mail*, 254—4th St., Jersey City, N. J.
MURRAY, Thos. E., Jr. ('32), Receiver, Interborough Rapid Transit Co., 165 Broadway, New York; *for mail*, 800 St. Marks Ave., Brooklyn.
MUSCARELL, R. Vincent (J'28), Draftsman, Babcock & Wilcox Co., 19 Rector St., New York; *for mail*, 1400 E. 34th St., Brooklyn.
MUSCHENHEIM, Fred'k A. ('15), Pres., Hotel Astor, Times Sq.
MYERS, David Moffat ('07; '12), Cons. Engr., Orrok, Myers & Shoudy, Associates, 21 E. 40th St.
MYERS, Jas. (A'26), Indus. Sec., Comm. on Social Serv., Fed. Council of Churches of Am., 105 E. 22nd St.
NAUGLE, John J. ('24), Pres., Suchar Process Corp., 72 Wall St.
NAUMBURG, Robt. E. ('17; '24), M. E., Jonas & Naumburg Corp., 516 W. 35th St.; *for mail*, 35 W. 90th St.
NAYLOR, Geo. M. ('20), Pres., Fairbanks Co., 393 Lafayette St., New York, N. Y.; *for mail*, 83 Warren Pl., Montclair, N. J.
NEAVE, Pierson M. ('03; '26), Secy., N. Y. Elec. Soc., Inc., 29 W. 39th St., New York, N. Y.; *for mail*, 46 Highland Ave., Glen Ridge, N. J.
NEFF, Elmer H. ('98), Life Member; M. E., N. Y. Mgr., Brown & Sharpe Mfg. Co., Rm. 902, 20 Vesey St.
NEFF, John P. ('13), V. P., Charge Engrg., Am. Arch Co., 60 E. 42nd St.
NEIDIG, Wm. N. ('16; '23), Engr., Lummus Co., 50 Church St., New York, N. Y.; *for mail*, 433 Mountain View Rd., Englewood, N. J.
NELSON, Parker C. ('29; '35), Engr., Internatl. Stand. Elec. Corp., 67 Broad St.
NESBITT, Hugh ('34), Engr., Globe Indemnity Co., 150 William St., New York, N. Y.; *for mail*, Ralston-Gladstone Rd., Mendham, N. J.
NESTLER, Peter J. ('16; '21), V. P., Vincent-Gilson Engrg. Co., 30 Church St., New York, N. Y.; *for mail*, 146 Monte Vista Ave., Ridgewood, N. J.
NEUBURGER, Herman Roy (J'34), 407 Audubon Ave.
NEUMANN, Arthur (J'34), 2767 Decatur Ave.
NEUMUNZ, Martin ('27), M. E., Mfrs. Rep., Rm. 412, 90 West St.
NEWELL, Frederick T. (J'34), Apt. 10F, 545 W. 11th St.
NEWELL, Wm. ('07; 16), Secy., Treas., Assigned Risk Pool, 1 Park Ave.; *for mail*, 1225 Park Ave.
NEWMAN, Paul F. ('33; '35), Oil Fuel Engr., Stand. Oil Co. of N. Y., Inc., 230 Park Ave., New York, N. Y.; *for mail*, 106 Johnson Dr. Ext., N. Plainfield, N. J.
NEXSEN, Randolph H. ('21), Ch. Power Engr., Charge Power Bur., Dept. of Pub. Serv., State of N. Y., 80 Center St.
NICASTRO, Geo. J. ('25; '36), Proposition Engr., Combustion Engrg. Co., Inc., 200 Madison Ave., New York, N. Y.; *for mail*, 975—1st Pl., Woodcliff, N. J.
NICHOLAS, Serafim (J'36), 1762 Crosby Ave.
NICHOLS, Wm. Wallace ('99), Asst. to Chmn., Allis-Chalmers Mfg. Co., 50 Church St.
NICOL, Geo. A., Jr. ('14; '35), Pres., Treas., Geo. A. Nicol Corp., Rms. 5416-17, 500—5th Ave.
NICOL, Norman C. ('19; '35), Sales Engr., Natl. Tube Co., 71 Broadway.
NICOLAI, A. Lewis (J'36), M. E., Performance Calculator, Combustion Engrg. Co., Inc., 200 Madison Ave.; *for mail*, 450 Riverside Dr.
NIELSEN, H. K. ('31), M. E., F. L. Smidth & Co., 24th Fl., 225 Broadway.
NIEMEYER, Edw. A. ('26; '33; '35), Engr., Production & Pur., Peabody Engrg. Corp., 580—5th Ave., New York; *for mail*, 85 Manhattan Ave., Crestwood.
NIEMITZ, Gerhard (J'29), Mech. Designer, Kennedy Van Saun Mfg. & Engrg. Corp., 2 Park Ave.; *for mail*, 3975 Carpenter Ave.
NIESSING, Wm. J. (J'36), Struc. Draftsman, Edw. G. Budd Mfg. Co., Philadelphia, Pa.; *for mail*, 154 Vermilyea Ave., New York, N. Y.
NIKONOW, John P. ('19), Pat. Atty., 3425 Giles Pl.
NITSCHKE, C. Robt. (J'32), Engr., Draftsman, Stand. Oil Co. of New York, Rm. 1540, 26 Broadway, New York, N. Y.; *for mail*, 222 Midwood Pl., Westfield, N. J.
NONES, Lynn W. ('31), East. Sales Mgr., Diamond Power Specialty Corp., 12 E. 41st St.
NONNENBRUCH, Otto ('22), New York Rep., De La Vergne Eng. Co., 120 Broadway.
NORDEN, Henry F. ('20; '24; '30), 616 Reiss Pl.
NORDENHOLT, Geo. F. ('26), Editor, Product Engineering, McGraw-Hill Publ. Co., 330 W. 42nd St.
NORDHEIMER, Albert ('16; '24; '35), Asst. Engr., N. Y. Central R. R. Co., Rm. 838, 466 Lexington Ave., New York; *for mail*, 225 Parkside Ave., Brooklyn.
NORMILE, Thos. H. ('19; '28; '30), Asst. E. E., Bd. Transportation, 49 Lafayette St.; *for mail*, 1699 Nelson Ave.
NORRIS, Clifton D. ('24; '35), Engr., Tex. Co., 135 E. 42nd St., New York, N. Y.; *for mail*, 412 Franklin Ave., Hasbrouck Heights, N. J.
NORRIS, Henry L. ('04; '21; '21), Dir. of Bldgs. & Grounds, Columbia Univ., 301 University Hall.
NOTT, Albin J. ('10; '17), Ford, Bacon & Davis, Inc., Cons. Engrs., 39 Broadway; *for mail*, 556 W. 140th St.
NOVOTNY, K. A. (J'35), Lab. Asst. in Engrg. Test, East River Sta., N. Y. Edison Co., Inc., New York; *for mail*, Ridgewood Terrace, Chappaqua.
OAKLEY, Alfred W. ('15; '25), Mgr., Tech. Dept., Merchants Refrig. Co., 17 Varick St.
OATLEY, Henry B. ('10), V. P., Superheater Co., 60 E. 42nd St., New York; *for mail*, 33 Arleigh Rd., Great Neck, L. I.
OBERG, Erik ('13; '19), Treasurer, '25-'35; Editor, Machinery, Secy., Industrial Press, 148 Lafayette St.
OBERT, Casin W. ('04; '14), Cons. Engr., Union Carbide & Carbon Research Lab., 30 E. 42nd St., New York; *for mail*, 122 N. Columbus Ave., Mt. Vernon.
ODELL, LeRoy L. ('28), Ch. Airport Engr., Pan Am. Airways System, 135 E. 42nd St.
OGDEN, John B. (J'34), 315 E. 88th St.
OHMES, Arthur K. ('09), Cons. Engr., Tenney & Ohmes, 101 Park Ave.
OHREN, Geo. A. (A'14), Apt. 4F, 635 Riverside Dr.

OLIVE, Theo. R. (J'31), Assoc. Editor, Chemical & Metallurgical Engineering, McGraw Hill Publ. Co., 330 W. 42nd St., New York, N. Y.; *for mail,* 147 Hamilton Rd., Ridgewood, N. J.
OLOFSON, E. Clifford (J'35), Customer Serv., Internatl. Business Mchs. Corp., 270 Broadway, New York; *for mail,* 209 Underhill Ave., Brooklyn.
OLSEN, Gustav E. (J'20), Mgr. Sales, Fitzgibbons Boiler Co., Inc., 570—7th Ave., New York; *for mail,* 6809 Amstel Blvd., Arverne, L. I.
OLSEN, Hartvig B. (J'33), Asst. Plant Engr., Eagle Pencil Co., 710 E. 14th St.; *for mail,* 630 W. 135th St.
O'NEIL, Fred'k W. ('01; '08), V. P., Ch. Engr., Ingersoll-Rand Co., 11 Broadway, New York, N. Y.; *for mail,* Compo Rd., Westport, Conn.
OPHULS, Fred ('14), Pres., Fred Ophuls & Associates, Inc., 112 W. 42nd St.
ORMAN, Hesen K. (J'30), Engr., N. Y. Dept. Water Supply, Gas & Elec., Municipal Bldg.; *for mail,* 360 Wadsworth Ave.
ORR, Alexander M. ('98; '23), Retired; 37 W. 44th St.
ORROK, Geo. A. ('02; F'36; H'36), Manager, '11-'14; Cons. Engr., Orrok, Myers & Shoudy, Associates, 21 E. 40th St.
ORT, Frank C. (J'28), Engr., Webster Tallmadge & Co., Inc., 50 Church St., New York, N. Y.; *for mail,* 2245 Berwyn St., Union, N. J.
ORTNER, Louis ('13), Ch. Engr., Dept. of Hospitals, City of N. Y., 10th Floor, Municipal Bldg., New York; *for mail,* 644—77th St., Brooklyn.
O'SHEA, Lieut. John (J'36), Engr. Officer, U. S. S. Tarpon, c/o Postmaster.
OSWALD, John Clyde ('29), Charge Design & Prod., Gregg Publ. Co., 270 Madison Ave.
OTTERSON, John E. ('17), Cons. Engr., 250 W. 57th St.
OVERTON, Wm. J. ('30), M. E., Montefiore Hospital, Gunhill Rd. & 210th St.
PAFFEN, Paul J. ('16), Mech. & Constr. Engr., Barrett Co., 40 Rector St.
PALAFOX, R. M. (J'35), 192 Claremont Ave.
PALATSKY, Geo. (J'33), 806 E. 9th St.
PALMER, Lew R. ('27), Conservation Engr., Equitable Life Assurance Society of U. S., Rm. 615, 393—7th Ave.
PALMER, Ralph M. ('33), V. P., Ferro-Nil Corp., 500—5th Ave.
PANAK, Leon P. (J'36), 2015 Grand Ave.
PAPEMFUSS, Chas. A. ('30; '31; '35), Ch. Engr., Fed. Reserve Bank of N. Y., Fed. Reserve P. O. Sta.
PARISH, William F. ('02; '04), Cons. Lubrication Engr., 456 Riverside Dr.
PARK, Franklin A. ('00), V. P., Singer Mfg. Co., 149 Broadway.
PARKER, Chas. M. (J'34), Secy., Tech. Com., Am. Iron & Steel Inst., 350—5th Ave., New York; *for mail,* 83-46—118th St., Kew Gardens, L. I.
PARKER, H. Sterling ('22; '27; '35), Supvr. of Bldgs., Harry Thoens & Co., Inc., 366—5th Ave., New York; *for mail,* 26 Woodruff Ave., Brooklyn.
PARKER, John ('21), Dist. Mgr., Stand. Mchy. Co. of Providence, R. I., 50 Church St., New York, N. Y.; *for mail,* 212 William St., E. Orange, N. J.
PARKER, John Castlereagh ('05; '09), V. P., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.
PARLETT, Raymond C. ('21; '25; '35), M. E., Sales Dept., Johns-Manville Corp., 22 E. 40th St.
PARLINI, Alex C. ('32; '35), Engr., Charge Design, Empire State Labs., 64 Fulton St.
PARR, Harry L. ('10), Prof. M. E., Columbia Univ.
PARRISH, Frank (A'30), Supvr. Inventories, U. S. Steel Corp., 71 Broadway.
PARRY, Henry L. ('27; '31; '35), Parry Engrg. Co., 154 Nassau St.
PARSONS, Charles Warren ('30; '35), Mgr., N. Y. Sales Dist., Republic Flow Meters Co., 101 Park Ave.
PARSONS, Geo. K. ('11), Pres., G. K. Parsons Corp., 65 Duane St.
PARSONS, Lester J. ('32; '35), Economy Engr., United Elec. Light & Power Co., Rm. 1473—S, 4 Irving Pl.
PARTINGTON, Jas. ('17), Mgr., Engrg. Dept., Am. Loco. Co., 30 Church St.
PASTORIZA, Hugh G. ('22), Exam. Engr., Coffin & Burr, Inc., 70 Pine St.
PATERSON, L. B. ('15; '21; '25), 4065 Carpenter Ave.
PATITZ, G. J. ('00; '07), Cons. & Supvg. Engr., Stand. Brands, Inc., 595 Madison Ave., New York; *for mail,* 1601 Maple Ave., Peekskill.
PATTERSON, Arthur W. ('97; '03), V. P., Engr. Co., 17 Battery Pl.
PATTERSON, Benj. S. (J'27), Tex. Co., 135 E. 42nd St., New York; *for mail,* 40 Bryant Ave., White Plains.
PATTERSON, Lawrence S. ('19; '35), Statistician, N. Y. State Pub. Serv. Comm., 80 Centre St., New York; *for mail,* 83 S. Village Ave., Rockville Center, L. I.
PATTERSON, Ward S. (J'26), Engr., Charge Contract Checking, Combustion Engrg. Co., Inc., 200 Madison Ave.
PAUGH, G. Ruel ('23), Salesman, Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail,* 325 Maolis Ave., Glen Ridge, N. J.
PAUL, Geo. W. (J'31), Arma Engrg. Co., 254—36th St., Brooklyn; *for mail,* 3656 Johnson Ave., New York.
PAULSEN, Alfred G. ('23), Ebasco Services, Inc., 2 Rector St.
PAYNE, Earl C. ('28), East. Sales Mgr., Consolidation Coal Co., 3300-30 Rockefeller Plaza.
PEABODY, Ernest H. ('00), Pres., Peabody Engrg. Corp., 580—5th Ave.
PEACE, Chas. S. ('29; '35), Engr., Smoot Engrg. Div., Republic Flow Meters Co., 101 Park Ave., New York; *for mail,* 27 Sherwood Rd., Rockville Centre, L. I.
PEARCE, Lester F. ('21; '35), Designer, Gen. Chem. Co., 40 Rector St., New York, N. Y.; *for mail,* 769—1st St., Westfield, N. J.
PEARMAN, S. Edw. ('29; '31; '35), 515 W. 110th St.
PEARSON, Oscar N. ('25; '32; '35), Engr., Hydrozone Co., Inc., 5949 Grand Central Term. Bldg., New York; *for mail,* 418 Jackson Ave., Endicott.
PECK, Clair B. (14; '35), Managing Editor, Railway Mechanical Engineer, Simmons-Boardman Publ. Co., 30 Church St.
PEGRAM, Geo. B. ('28), Prof. Physics, Columbia Univ.
PENDLETON, Miles S. (J'32), Sales Engr., Pendleton Associates, 4610 Grand Cent. Term. Bldg.
PENNEY, Harold D. ('13), Prop., Patents, 253 Broadway.
PEPER, John H. ('10; '16; '35), Ch. Engr., N. Y. Transit Co., Rm. 1275, 26 Broadway.
PERES, Alfred P. (J'35), Penn-Dixie Cement Corp., 60 E. 42nd St.; *for mail,* 1651 Montgomery Ave.
PERRET, Albert E. ('27; '35), 210 W. 107th St.
PERROTT, Wm. ('23), Constr. Mgr., U. S. Lines, Inc., 45 Broadway, New York, N. Y.; *for mail,* 961 Palisade Ave., Woodcliff, N. J.
PERRY, Harold S. ('24; '33; '35), Serv. Engr., Foster Wheeler Corp., 165 Broadway, New York, N. Y.; *for mail,* 27 Maple Ave., Glenbrook, Conn.
PERRY, Norvin ('31), Cons. Engr., 500—5th Ave.
PERSON, Harlow S. ('24), Taylor Soc., 29 W. 39th St.
PERSON, Howard A. ('19; '21; '35), Acting Ch. Engr., Fed. Light & Transmission Co., 70 Pine St.
PETERS, A. Harold (J'36), M. E., Charge Maint., Ellen & Jeffery, Inc., 33 W. 42nd St., New York; *for mail,* 247 Nassau Ave., Manhasset, L. I.
PETERS, Heber C. ('16), Retired; 501 W. 113th St.
PETERSEN, Carl E. ('18; '29; '31), Asst. to V. P., Newport News Shipbldg. & Dry Dock Co., 90 Broad St.
PETERSON, Andrew I. ('30; '35), Asst. Prof. Engrg. Economics; Property Supvr., N. Y. Univ., 181st St. & University Ave., New York; *for mail,* 28 Sagamore Rd., Bronxville.
PETERSON, Arthur J. (J'24), Foreign Dept., Corn Exchange Bank Trust Co., 13 William St., New York; *for mail,* 1125—80th St., Brooklyn.
PETROFF, Peter A. ('30), Engr., Charge Fed. Govt. Business, P. R. Mallory Co., 6 E. 45th St.; *for mail,* 170 Claremont Ave.
PHELAN, John Joseph (J'30), 464 E. 141st St.
PHELAN, Thos. H. (J'30), Natl. Broadcasting Co., Inc., 711—5th Ave., New York, N. Y.; *for mail,* 48 Lenox Ave., Maywood, N. J.
PHELPS, Chas. C. ('09; '16; '35), Mfrs. Agent, 125 Church St.
PHILLIPS, Ellis L. ('01; '26), Pres., Long Island Ltg. Co., 50 Church St.
PHILLIPS, G. W. Macpherson ('27), c/o Dr. W. M. Grosvenor, 50 E. 41st St., New York, N. Y.; *for mail,* 166 Summit Rd., Elizabeth, N. J.
PHYL, Jos. ('27; '35), M. E., W. Va. Pulp & Paper Co., 230 Park Ave.; *for mail,* 1455 Undercliff Ave.
PIACITELLI, Jos. A. ('23; '25; '35), Cons. Engr., 7 E. 42nd St.
PICUCCI, Jos. A. (J'26), Engr., Charge Design, Consltd. Laundries Corp., 122 E. 42nd St.
PIEKENBROCK, Rudolf A. (J'29), M. E. & Layout, Frederick L. Smith, 21 E. 40th St., New York; *for mail,* 86-22 Dongan Ave., Elmhurst, L. I.
PIERCE, Frederic E. ('09), Rm. 720, 522—5th Ave.
PIERCE, R. C. ('20), Cons. Engr., 929 Park Ave.
PIHLMAN, A. A. ('28; '35), Supvr., Consltd. Edison Co. of N. Y., Inc., 130 E. 15th St.
PIRNIE, Jas. A. (J'21), N. Y. Dist. Rep., Indus. Bur. of Baltimore, 122 E. 42nd St.; *for mail,* 164 E. 72nd St.
PLACE, C. Allen ('31), Field Engr., Stevenson, Jordan & Harrison, 19 W. 44th St.; *for mail,* 152 E. 22nd St.
PLACE, Clyde R. ('07; '22), Cons. Engr. Rm. 2122, 420 Lexington Ave.
PLASSE, Herman (J'33), Sales Engr., Boig & Hill, Inc., 87 Barclay St.
PLATT, John ('89; '90), Cons. Engr., 75 West St.
POGUE, Jos. E. ('21), V. P., Chase Natl. Bank, 18 Pine St.
POLAKOV, Nicholas N. ('24), Asst. Engr., Dept. Sanitation, City of New York, 125 Worth St., New York; *for mail,* Unit 1, St. George Gardens, Apt. E 5, St. George, S. I.
POLIAKOFF, Rouvime ('21), M. E., 1071—6th Ave.
POLLARD, R. Spotswood (J'24), Sales Engr., Pyle Natl. Co., 3625 Grand Central Term., New York, N. Y.; *for mail,* 8 Summit St., E. Orange, N. J.
POPE, Jos. ('15; '23), Cons. Engr., Stone & Webster Engrg. Corp., 90 Broad St.
POPKIN, Martin E. ('27; '35), Indus. Economist, 1—5th Ave.
PORTER, David B. ('16; '25), Assoc. Prof. Indus. Engrg., N. Y. Univ., University Heights.
PORTER, H. Hobart ('02), Partner, Sanderson & Porter, 52 William St.
POSSELT, Ejnar ('07; '13), V. P., Lone Star Cement Corp., 342 Madison Ave.
POST, Robt. C. ('19), Pres., Post & McCord, 1011 Park Ave.
POTTER, Erford M. ('17; '35), V. P., Ivan T. Johnson Co., Inc., 95 Madison Ave.
POTTER, Gordon L. (J'35), Draftsman, J. O. Ross Engrg. Corp., 350 Madison Ave.
POTTER, John D. ('23; '25; '35), Installation Engr., Elec. Research Products, Inc., 250 W. 57th St., New York, N. Y.; *for mail,* Box 122, Linden, N. J.
POUCH, Leslie O. (J'31), F. P. Platt & Bros., Architects, 221 W. 57th St., New York; *for mail,* 630 Metropolitan Ave., Staten Island.
PRAHL, Fredk. A., Jr., (J'36), 175 W. 93rd St.
PRANGE, Chas. H. ('19; '23; '35), V. P., Charge Research, Gen. Mgr., Austenal Labs., Inc., 34 W. 33rd St., New York, N. Y.; *for mail,* Gap View Rd., Short Hills, N. J.
PRATT, Auguste G. ('15), Pres., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail,* 345 Walnut St., Englewood, N. J.
PRATT, Harlan A. ('27), East. Mgr., R. R. Dept., Ingersoll-Rand Co., 11 Broadway, New York, N. Y.; *for mail,* 910 Belvidere Ave., Plainfield, N. J.
PRESCOTT, Arthur T. (A'22), Engr., Charge Sales & Mfr., J Edw. Ogden Co., 147 Cedar St., New York, N. Y.; *for mail,* 312 Park Ave., E. Orange, N. J.
PRESDEE, John J., ('26; '35), Squad Leader, Engrg. Dept., Combustion Engrg. Co., Inc., 200 Madison Ave., New York; *for mail,* 10 Cedar Pl., Tuckahoe.
PRETOT, Armand V. ('25; '32; '35), Engr., Charge Design, Johns-Manville Corp., 22 E. 40th St.
PRICE, Harry (J'31), Pat. Lawyer, Rm. 2618, 420 Lexington Ave.
PRICE, Jos. ('28), Ch. Engr., Griscom-Russell Co., 285 Madison Ave.
PRIMROSE, John ('07), Vice Chmn. Bd., Foster Wheeler Corp., 165 Broadway.
PRINCE, Jerome S. (J'33), Audit Dept., Prince, Jagendorf, Greene, Inc., 369 E. 149th St.; *for mail,* 220 Boscobel Pl.
PRINDLE, Edwin J. ('10), Sr. Mem., Prindle, Bean & Mann, 40 Wall St.
PRINS, Anthony W. ('27; '35), East. Dist. Mgr., Novo Eng. Co., 167th & Sedgwick Ave., New York; *for mail,* 843 James St., Pelham Manor.
PROSSER, Roger D. ('30; '35), Mem. Firm, Thos. Prosser & Son, 15 Gold St.
PURDIE, David J. ('21; '35), Dist. Sales Mgr., Builders Iron Fdy., 20 Vesey St., New York, N. Y.; *for mail,* 75 Personette Ave., Verona, N. J.
PURDY, Randall B. ('25; '32), Asst. Editor, Power, McGraw-Hill Publ. Co., 330 W. 42nd St., New York; *for mail,* 224-05—139th Ave., Laurelton, L. I.
QUACKENBUSH, E. Schuyler ('17; '25), 87 Hamilton Pl.
QUIGLEY, W. S. ('13), Pres., Quigley Co., Inc., 56 W. 45th St.
QUIRK, Clinton H. ('17; '35), East. Rep., Trane Co., 250 E. 43d St.
RAABE, Miss Edythe R. (J'30), Personnel Dept., Long Lines, Am. Tel. & Tel. Co., 15 Dey St., New York, N. Y.; *for mail,* 476 Rutherford Ave., Lyndhurst, N. J.
RACHALS, Walter ('18), Asst. Ch. Engr., U. S. Steel Corp., Rm. 1801, Empire Bldg., 71 Broadway.
RADER, Earl D. ('29), Pat. Lawyer, 420 Lexington Ave.
RADOM, Gregory L. ('30; '35), Engr., Charge Design, Prudential Iron Wks., Inc., 530 Truxton St.; *for mail,* 108 Marcy Pl.
RAETSCH, B. Arthur (J'36), M. E. in Engrg. of Mfg. Dept., West. Elec. Co., Inc., 2500 Broening Highway, Baltimore, Md.; *for mail,* 2836 Middletown Rd., New York, N. Y.

BAETZ, S. J. ('21), Supvr., R. R. Car Maint., Independent Subway, Bd. of Transportation, City of New York, 3961—10th Ave.; *for mail,* 518 Ft. Washington Ave.
RAISCH, Wm. ('24; '34), V. P., Charge Engrg., Mun. Sanitary Serv. Corp. & Decarie Incinerator Corp., 155 E. 44th St., New York; *for mail,* 6945 Manse St., Forest Hills, L. I.
RAISLER, Robt. K. ('26; '33; '35), Treas., Raisler Htg. Co., 129 Amsterdam Ave.; *for mail,* 25 E. 77th St.
RAMAGE, Edwin C., Jr. ('22; '27; '32), Engr., Westvaco Chlorine Products, Inc., 405 Lexington Ave.
RAMSEY, Geo. ('16), Partner, Ramsey, Kent, Chisholm & Lutz, Pat. Lawyers, 233 Broadway.
RAUTENSTRAUCH, Walter ('04; '11), Prof. Indus. Engrg., Columbia Univ., New York, N. Y.; *for mail,* 235 Dorin Court Rd., Palisade, N. J.
REARICK, C. B. ('92; '01), Prop., Chas. B. Rearick Co., 30 Church St.
REDMERSKI, Edmund S. ('27; '34; '35), Sales Engr., Reeves Pulley Co. of N. Y., Inc., 76 Dey St., New York, N. Y.; *for mail,* 238—13th St., Jersey City, N. J.
REED, Hugh D. (J'21), Combustion Engrg. Co., Inc., 200 Madison Ave.
REED, M. J. (29; '35), Secy., Treas., Diesel Eng. Mfrs. Assn., 2 W. 45th St.
REED, Wm. E. ('98), Secy., Treas., Morewood Realty Holding Co., Suite 3001, 551—5th Ave.; *for mail,* 175 W. 72nd St.
REID, Harry (A'22), Pres., Harry Reid & Co., Inc., 150 Broadway.
REILLY, J. Harry (J'25), Engr., Kimball & Cucci, 205 E. 42nd St., New York, N. Y.; *for mail,* 14 Watson Ave., E. Orange, N. J.
REISMAN, Fred'k W. ('26; '28), Pres., Keystone Refractories Co., Inc., 120 Liberty St.
REITER, Bela Z. ('29), Asst. Mgr., Illustration Dept., McGraw-Hill Publ. Co., Inc., 330 W. 42nd St., New York, N. Y.; *for mail,* 445 Claremont Ave., Teaneck, N. J.
REKER, Carl H. ('21; '27; '35), Ch. U. S. Rate Sponsor, Ebasco Services, Inc., 2 Rector St.
REMELMAN, Eugene (J'32), Water Tender, Interborough Rapid Transit Co., 600 W. 59th St.; *for mail,* 33 Convent Ave.
RENNER, Roland B. ('06; '15; '27), Dist. Sales Mgr., Jeffrey Mfg. Co., 30 Church St., New York, N. Y.; *for mail,* 22 Ridgewood Terrace, Maplewood, N. J.
RENNIE, Robt. ('22), Engr., Am. Loco. Co., 30 Church St., New York, N. Y.; *for mail,* 110 Hazelton St., Ridgefield Park, N. J.
RENWICK, Edward B. ('14), Retired; 302 Broadway.
REOCH, Albert G. ('24; '35), Delaware-Lackawanna & West. Coal Co., 271 Church St., New York; *for mail,* 99 Connecticut Ave., Freeport, L. I.
RESWICK, Maurice ('32), Lub. Engr., Stand. Oil Co. of N. J., 26 Broadway, New York; *for mail,* 16 Elizabeth Ave., Staten Island.
REWALT, John K. ('24), Sales Engr., Philadelphia Gear Wks., Inc., 330 W. 42nd St.
REYNOLDS, Herbert B. ('12; '19; '22), M. E., Motive Power Dept., Interborough Rapid Transit Co., 600 W. 59th St.
REYNOLDS, Wm. Chas. (J'30), Bethlehem Shipbldg. Co., 25 Broadway.
REYNOLDS, Winfred E. ('28), Mgr., Valuation & Reports Dept., Ford, Bacon & Davis, Inc., 39 Broadway.
RHINE, Carl K. (J'32), Gen. Chem. Co., 40 Rector St.; *for mail,* 317 W. 100th St.
RHODES, Geo. H. ('13; '25), Design Engr., Natl. Biscuit Co., 449 W. 14th St.
RHODES, Geo. I. ('19), V. P., Ford, Bacon & Davis, Inc., 39 Broadway.
RICE, Geo. L. ('19; '35), 562 W. 113th St.
RICHARDSON, Ammi C. ('13; '19), Asst. Gen. Engr., Am. Thread Co., 260 W. Broadway.
RICHARDSON, Percy L. (J'32), Engr., Commercial Dept., N. Y. Edison Co., Inc., 4 Irving Pl., New York; *for mail,* 89-14—34th Ave., Jackson Heights, L. I.
RICHMOND, Robt. L. (J'35), 59 W. 10th St.
RICHTER, Wm. Walter ('30; '35), Turbine Rm. Engr., N. Y. Edison Co., Inc., 14th St. & East River, New York; *for mail,* 24-46 Butler St., E. Elmhurst, L. I.
RICKETSON, Wm. E. ('16), Equip. Valuation Engr., N. Y. Cent. Lines, Rm. 1015, 466 Lexington Ave.
RICKETTS, Edwin B. ('08; '16), Research Engr., N. Y. Edison Co., Inc., 4 Irving Pl.
RICKMAN, Arthur A. (J'34), Asst. Engr., H. Z. Altberg, Inc., 1776 Broadway; *for mail,* 1945 Davidson Ave.
RIGDON, Carl ('07; '16), Engr., Engrg. Dept., Am. Agri. Chem. Co., Graybar Bldg., 420 Lexington Ave., New York, N. Y.; *for mail,* 171 Montclair Ave., Montclair, N. J.
RILEY, Champlain L. ('17), V. P., Treas., Clark, MacMullen & Riley, Inc., 101 Park Ave.
RILEY, Russell A. (J'34), Engr., Charge Maint., Post Office Dept., Rm. 302, 33d St. & 8th Ave., New York; *for mail,* 186-18—115th Ave., St. Albans, L. I.
RISER, Volney O. (J'30), Lamp Inspc., Elec. Testing Labs., 80th St. & East End Ave., New York, N. Y.; *for mail,* 1051 Broad St., Bloomfield, N. J.
RIZZO, Jos. F. (J'33), Ch. Engr., Dir. of Sch., Empire Diesel Schs., Inc., 630 Dean St., Brooklyn; *for mail,* 3565 Eastern Blvd., New York.
ROBB, A. R. ('24; '35), Eng. Dept., Natl. Biscuit Co., 449 W. 14th St., New York; *for mail,* 57 E. Oxford St., Valley Stream, L. I.
ROBBA, Walter Frank ('27; '35), M. E., Charge Maint., Geo. A. Bowman, Inc., 100 W. 42nd St.; *for mail,* 647—8th Ave.
ROBBINS, John F. ('19; '35), 32 W. 91st St.
ROBERTS, A. Perry ('21; '25; '30), Mgr., N. Y. Office, Hardie-Tynes Mfg. Co., 233 Broadway, New York, N. Y.; *for mail,* 132 Tenafly Rd., Tenafly, N. J.
ROBERTS, Arthur ('22; '26; '35), Ch. Engr., Preferred Utilities Co., 33 W. 60th St., New York, N. Y.; *for mail,* 111 N. Pleasant Ave., Ridgewood, N. J.
ROBERTS, Arthur Llewellyn ('14), Charge R. R. Devel., Internatl. Nickel Co., 67 Wall St.
ROBERTS, Richard Francis ('15; '35), Indus. Engr., Brown Instruments Div., Minneapolis Honeywell Regulator Co., 801 2nd Ave., New York, N. Y.; *for mail,* 136 Cleveland St., Orange, N. J.
ROBINSON, Jos. ('23), Pres., Robinson Connector Co., Inc., 1907 Park Ave.
ROBINSON, Walter E. ('28; '35), Head of Copy, "Machinery," Indus. Press, 140 Lafayette St.
ROCKEFELLER, Harry E. ('27; '36), Mgr., Process Devel. Dept., Linde Air Products Co., 30 E. 42nd St.
RODERICK, Edw. M. ('27; '35; '35), M. E., Combustion Engrg. Co., Inc., 200 Madison Ave.; *for mail,* 215 W. 23d St.
RODGER, W. Neale (J'28), Indus. Engr., Ford, Bacon & Davis, Inc., 39 Broadway, New York; *for mail,* 631 Delamere Pl., Brooklyn.
RODMAN, Nicholas ('22; '26; '35), Ch. Mar. Inspr., N. Y., New Haven & Hartford R. R., Pier 14, North River.
RODMAN, Robt. W. ('22), Supt., Plant Operation, Bd. of Education, City of N. Y., 500 Park Ave.
RODNITE, John J. (J'31), Sales Engr., Neptune Meter Co., 50 W. 50th St., New York, N. Y.; *for mail,* 250 Stuart St., Boston, Mass.
ROE, Jos. W. ('02), *Melville Medallist,* '29; Prof. Indus. Engrg., N. Y. Univ., University Heights.
ROE, Ralph Coats ('32), Design Engr., Elec. Mgmt. & Engrg. Corp., 84 William St., New York, N. Y.; *for mail,* 167 Rockwood Pl., Englewood, N. J.
ROEMMELE, Herbert F. ('25; '36), Asst. Prof. M. E., Charge M. E. Labs., Cooper Union, 41 Cooper Sq.
ROGERS, Arlester B. ('27), Combustion Engr., Elk Tanning Co., Masonic Bldg., Ridgway, Pa.; *for mail,* 27 Spruce St., New York, N. Y.
ROGERS, Geo. B. (J'29), Salesman, Indus. Lub. Oil, Stand. Oil Co. of N. Y., 544 E. 138th St.; *for mail,* 44 Gramercy Park.
ROGOFF, Julian (J'31), Engr., Charge Research, Devel. & Test, Burndy Engrg. Co., Inc., 305 E. 45th St.; *for mail,* 145 Seaman Ave.
ROLLE, Carl (J'36), Internatl. Nickel Co., 67 Wall St.
ROMANOW, Frank F. (J'33), Tech. Staff, Bell Tel. Labs., Inc., 463 West St., New York; *for mail,* 20 Lincoln Ave., W. Hempstead, L. I.
RORVIG, Kenneth C. (J'33), Planning Engr., R. H. Macy & Co., Inc., Broadway at 34th St., New York; *for mail,* 1725 E. 23rd St., Brooklyn.
ROSCOE, Harry W. ('29; '35), West. Elec. Co., Inc., 195 Broadway, New York, N. Y.; *for mail,* 482 Windsor Rd., Wood-Ridge, N. J.
ROSENBERG, Heyman ('27), Secy., M. E., Charge Prod., Parker-Kalon Corp., 200 Varick St.
ROSENBERG, S. ('20), Inspr., Mech. & Elec. Equip., Panama Canal, 24 State St.; *for mail,* 3440 Broadway.
ROSENCRANTS, Fay H. ('13; '18; '25), Combustion Engrg. Co., Inc., 200 Madison Ave.
ROSENSTEIN, Jerome Henry (J'35), 101 Central Park West.
ROSENTHAL, Rudolph ('23; '35), Retired; 50 E. 83rd St.
ROSENZWEIG, Siegfried ('14), Pres., Korfund Co., 4815—32nd Pl., Long Island City; *home address,* 35 W. 90th St., New York.
ROSS, D. P. (J'36), Estimator, Display-Finishing Co., 21-30—44th Rd., Long Island City; *for mail,* 4002 Carpenter Ave., New York.
ROSS, John O. ('20), Chmn. Bd. Dirs., Ross Industries Corp., 350 Madison Ave.
ROTH, Herbert ('29; '35), Asst. Secy., Auto Strop Safety Razor Co., Inc., 656—1st Ave., New York; *for mail,* 455 Marlborough Rd., Yonkers.
ROTHMALER, Oswald ('26), Secy. & Dir., Ertel Engrg. Corp., 120 E. 16th St., New York; *for mail,* 197 Rugby Rd., Brooklyn.
ROTHSCHILD, W. G. (J' 29), Test. Engr., Interborough Rapid Transit Co., 600 W. 59th St., New York, N. Y.; *for mail,* 1203 Park Ave., Hoboken, N. J.
ROWE, Harold E. (J'16), Ch. Draftsman, H. S. Bell, Petroleum Engr., 233 Broadway; *for mail,* 10 Mitchell Pl.
ROWELL, Kendall B. ('30; '35), Engr., Elec. Loco. & Car Design, N. Y. Cent. R. R. Co., Rm. 1454, 466 Lexington Ave.
ROWLAND, D. J. ('23), Partner, Rowland & Burns, 39 Cortlandt St.
ROYER, Dan L. ('29; '35), Ch. Engr., Ocean Accident & Guarantee Corp., Ltd., 1 Park Ave.
ROZETT, Wm., Jr. (J'33), Salesman, Shell Union Oil Co., 1 Edison Ave., Mt. Vernon; *for mail,* 847 E. 232nd St., New York.
RUCH, Alan J. (J'27), Service Engr., Combustion Engrg. Co., Inc., 200 Madison Ave.
RUDOLPHI, Frank ('13), Gen. Cons. Engr., Am. Can Co., 230 Park Ave.
RUGGE, Geo. J. ('20; '26; '35), M. E., & Purch. Agt., Moody Engrg. Co., Inc., 90 West St.
RUSHMORE, David B. ('97; '03), University Club, 1 W. 54th St.
RUSSELL, J. J. ('33), Charge, Maint. & Constr., Cent. Hanover Bank & Trust Co., 60 Broadway, New York, N. Y.; *for mail,* 1605 Lemoine Ave., Ft. Lee, N. J.
RYAN, Wm. J. ('12; '36), 403 W. 115th St.
SAATHOFF, Geo. W. ('22), Ch. Constr. Engr., Cities Service Co., 60 Wall St.
SAHMEL, Viggo ('14), Ch. E. E., F. L. Smidth & Co., 225 Broadway.
SALISBURY, Donald W. ('29), Pres., Southwestern Engrg. Co., Inc., 90 West St.
SALMA, Emanuel A. (J'32), Instr. M. E., Cooper Union, Astor Pl.; *for mail,* 230 E. 71st St.
SALMON, Philip A. ('25; '35; '35), Sales Engr., Ingersoll-Rand Co., 11 Broadway.
SALMONSEN, Robt. ('21; '27; '32), M. E., F. L. Smidth & Co., 225 Broadway.
SALO, Eric A. (J'30), Jr. Engr., Dept. Power Plants, Mech. Test Div., Hell Gate Generating Sta., United Elec. Light & Power Co., E. 134th & Locust Ave.; *for mail,* 2542 University Ave.
SAMPSON, Henry H. (J'28), Asst. Commercial Engr., Utilization Dept., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl., New York, N. Y.; *for mail,* 419 Edgewood Ave., Westfield, N. J.
SAMPSON, J. Jos. (J'32), Teacher, Textile High Sch., 351 W. 18th St.; *for mail,* 342 Madison Ave.
SAMPSON, Winslow F. ('25), 5 Prospect Pl.
SANBORN, Elmer E. ('31; '35), Automotive Engr., Natl. Carbon Co., 30 E. 42nd St., Rm. 1307, New York, N. Y.; *for mail,* 119 Tacoma Circle, Asheville, N. C.
SANDERS, Geo. E. (J'34), 102 W. 85th St.
SANDERS, Jas. Corbin ('23; '35), Engr., 90 Worth St.
SANDERSON, Robt. R. ('22; '35), Engr., 131 Riverside Dr.
SANFORD, Geo. R. ('10), V. P., Atmospheric Nitrogen Corp., 61 Broadway.
SANTRY, Jos. V. ('35), Exec. V. P., Combustion Engrg. Co., Inc., 200 Madison Ave.
SAPONARA, Domenick (J'31), Test Engr., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl., New York, N. Y.; *for mail,* c/o Floyd-Wells Co., Royersford, Pa.
SARGENT, Fitz Wm. ('93), Ch. Engr., Am. Brake Shoe & Fdy. Co., 230 Park Ave., New York, N. Y.; *for mail,* Box 317, Mahwah, N. J.
SAVOYE, Chas. U. ('19; '26), Babcock & Wilcox Co., 19 Rector St., New York.; *for mail,* 350 Central Ave., Hackensack, N. J.
SAVRDA, Chas. M. ('27; '35), M. E., Atlantic Coast Fisheries Corp., 307 Water St., New York; *for mail,* 148 N. 5th Ave., Bay Shore, L. I.
SAWYER, R. Tom ('30; '35), Sales Engr., Diesel Loco., Am. Loco. Co., 30 Church St.
SAWYER, Willits H. ('28), 30 Broad St.
SCHAEFER, Conrad B. (J'27), Auditor, Austin Co., Rm. 1500, 19 Rector St.
SCHAFF, Frederic A. ('15; '26), Pres., Superheater Co., 60 E. 42nd St.
SCHAFFER, Bernard (J'33), 1091 Longfellow Ave.
SCHARNAGEL, Herman J. ('19), 111 W. 11th St.
SCHECKENBACH, John A. V. ('17; '21), Asst. V. P., Charge Prod., Am. Car. & Fdy. Co., 30 Church St.
SCHEEL, H. V. R. ('09; '13), Cons. Engr., Rm. 4306, 233 Broadway.
SCHIER, Oscar B., 2nd (J'32), Consltd. Edison Co. of N. Y., Inc., 40th St. & 1st Ave.
SCHIEREN, G. Arthur ('30), V. P., Chas. A. Schieren Co., 30 Ferry St., New York; *for mail,* E. Shore Road, Great Neck, L. I.

SCHILLING, Bernhard ('22; '35), Designing Engr., Combustion Utilities Corp., 60 Wall St.; *for mail*, 789 E. 158th St.
SCHLANK, Elias ('36), Owner, Elec. Supvr. Co., 113 W. 42nd St.
SCHLAYER, Earl G. (J'25), Engr., Penn. Coal & Coke Corp., 70 E. 45th St., New York; *for mail*, 269 Madison Rd., Scarsdale.
SCHLICK, Louis F. ('26; '33), Ch. Engr., U. S. Lines, Inc., 45 Broadway, New York, N. Y.; *for mail*, 900 Ave. C., Bayonne, N. J.
SCHLOSS, Newton L. ('16), Arch.-Engr. Consultant, 5629 Grand Cent. Terminal.
SCHMIDT, Edgar H. (J'32), Otis Elev. Co., 260—11th Ave.; *for mail*, 338 E. 142nd St.
SCHMIDT, Geo. G. ('13; '16; '35), Sr. Partner, Connolly & Schmidt, 10 W. 37th St.
SCHMIDTCHEN, Robt. P. ('28), Engr., Charge Mch. Design, Eagle Pencil Co., 710 E. 14th St., New York; *for mail*, 129 Rockaway Pkwy., Valley Stream, L. I.
SCHNEIDER, Carl A. ('26), Cons. Engr., Ford, Bacon & Davis, Inc., Rm. 1800, 39 Broadway.
SCHNEIDER, Milton L. (J'29), Inspec. Engr., N. Y. Steam Corp., 280 Madison Ave.; *for mail*, 617 W. 179th St.
SCHNEIDER, Robt. Siis (J'28), Oiler, Interborough Rapid Transit Co., Inc., 600 W. 59th St., New York; *for mail*, 11903—103rd Ave., Richmond Hill, L. I.
SCHNEITTER, Lee ('21; '25; '35), Plant Betterment Engr., Ebasco Services, Inc., 2 Rector St.
SCHODER, Erlo F. (J'30), Mar. Estimator, Fed. Shipbldg. & Dry Dock Co., 25 Broadway, New York, N. Y.; *for mail*, 407 Highland Ave., Palisades Park, N. J.
SCHOENFELDT, Wm. C. ('22; '29; '35), Gen. Mgr., Ritz Oil Burner Co., Inc., 14 Wooster St.; *for mail*, 1041 Trinity Ave.
SCHOENING, Fred'k C. ('20; '23; '35), 181 St. George's Crescent St.
SCHORLING, Henry F. ('20; '26), M. E., Alco Products, Inc., 30 Church St.
SCHREIBER, Carl T. ('31), Sales Engr., Dri-Steam Valve Sales Corp., 70 E. 45th St., New York; *for mail*, 8601—94th St., Woodhaven, L. I.
SCHROEDER, Henry ('35), Design Engr., Combustion Engrg. Co., Inc., 200 Madison Ave., New York; *for mail*, 40-20—82nd St., Jackson Heights, L. I.
SCHUELER, Lyle B. (J'29), Engr., Babcock & Wilcox Co., 85 Liberty St.
SCHUETZ, Fred'k F. ('03; '26), Solicitor of Patents, 233 Broadway.
SCHULLSTROM, T. ('27), Foster Wheeler Corp., 165 Broadway; *for mail*, 256 Seaman Ave.
SCHULTE, Max J. L. ('16; '21; '35), V. P. & Gen. Mgr., Rawlplug Co., Inc., 98 Lafayette St.
SCHUYLER, Wm. A. ('21; '35), Sale of Spec. Mchy., 250 W. 57th St.
SCHWAB, Chas. M. ('99; Hon. '18), President, '27; Chmn., Bethlehem Steel Corp., 25 Broadway.
SCHWARTZ, Arnold A. ('21), Pres., Art Color Ptg. Co., 130 W. 42nd St., New York, N. Y., and Dunellen, N. J.; *for mail*, 1159-91 Woodland Ave., Plainfield, N. J.
SCHWARTZ, Sidney T. (J'28), Serv. Engr., Babcock & Wilcox Co., 130 Cedar St.
SCHWARZ, Elmer H. ('27), Cons. Engr., Hammer & Schwarz, 80 John St.
SCHWENKE, Heino O. L. (J'29), 180 W. 167th St.
SCOTT, Geo. Elliott (J'34), Sales Engr., Ingersoll-Rand Co., 11 Broadway.
SCOTT, G. J. (J'28), Supv., Power Prod. Dept., Johns-Manville Internatl. Corp., 22 E. 40th St.
SCOTT, Rossiter S. ('15), Cons. Water Engr., S. R. Dresser Mfg. Co., Bradford, Pa.; *for mail*, 112 Park Ave., New York, N. Y.
SEARLES, Elwood F. ('24; '35; '35), Engr. in Gen. Office, Sales Dept., Babcock & Wilcox Co., 19 Rector St., New York, N. Y.; *for mail*, 350-B Plaza Rd., Fairlawn, N. J.
SEBALD, Leslie E. ('19; '25; '35), Asst. Ch. Engr., Griscom-Russell Co., 285 Madison Ave., New York, N. Y.; *for mail*, 20 Garfield Pl., Ridgewood, N. J.
SEDGWICK, Earl H. ('99; '25), Engr. Draftsman, Am. Car & Fdy. Co., 30 Church St., New York, N. Y.; *for mail*, 168 Howard St., Passaic, N. J.
SEE, A. B. ('09), Chmn. Bd. Dirs., A. B. See Elev. Co., Inc., 419—4th Ave.
SEELIG, Alfred E. ('21), Pres. & Gen. Mgr., L. J. Wing Mfg. Co., 154 W. 14th St.; *for mail*, 310 Convent Ave.
SEIDL, Frank (J'28), Draftsman, N. Y. Edison Co., Inc., 130 E. 15th St., New York, N. Y.; *for mail*, 6733—79th St., Ridgewood, L. I.
SEIGLE, Wm. R. ('14), Gen. Factory Mgr., Johns-Manville Corp., 292 Madison Ave., New York; *for mail*, P. O. Box 42, Mamaroneck.
SELLEW, Welles H. (J'13), M. E., Bell Tel. Labs., Inc., 463 West St., New York; *for mail*, 49 Cambridge Pl., Brooklyn.
SELLMAN, Nils T. ('14; '23), Asst. V. P., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.
SENGSTAKEN, J. H. ('15; '25; '35), M. E., Superheater Co., 60 E. 42nd St.
SETCHKIN, Nicholas P. ('31), M. E., Gibbs & Cox, 21 West St.; *for mail*, 49 W. 89th St.
SEWARD, Robt. B. ('23), Partner, Brown & Seward, 270 Broadway.
SHAFER, Clinton, Jr. (J'25), Inspr. Engrg., Bell Tel. Labs., Inc., Bethune & West Sts.; *for mail*, 183 Pinehurst Ave.
SHEAFFER, Ervin F. ('35), Draftsman, Griscom-Russell Co., 285 Madison Ave., New York, N. Y.; *for mail*, 629 Chestnut St., Roselle Park, N. J.
SHELDON, Otis C. ('32; '35), Dist. Mgr., Riley Stoker Corp., 103 Park Ave.
SHELTON, N. Thomas (J'32), Res. Engr., Time Study & Personnel, Indus. Mgmt. Engrs., Inc., 70 Pine St., New York, N. Y.; *for mail*, 154 Algoma Blvd., Oshkosh, Wis.
SHEPARD, F. S. ('21), Refinery Opera., Socony-Vacuum Oil Co., Inc., 26 Broadway.
SHEPARD, Ralph H. ('32; '35), Engr., Nathan Mfg. Co., 416 E. 106th St., New York; *for mail*, 56 Pondfield Rd., W., Bronxville.
SHERBAN, Daniel V. ('25), Engr., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail*, Route 1, Keyport, N. J.
SHERMAN, Geo. S. ('25), Supt. Maint., Jas. A. Hearn & Son, 26 W. 13th St., New York, N. Y.; *for mail*, 379 Cross St., Westbury, L. I.
SHERWOOD, Lieut. Col. Edw. L. ('20; '35), Pres., E. L. Sherwood Co., 24 W. 40th St., New York, N. Y.; *for mail*, 215 Prospect St., Ridgewood, N. J.
SHINKLE, Vincent G. ('27), Cons. Petroleum Engr., 122 E. 42nd St.; *for mail*, 600 W. 111th St.
SHOREY, John A. ('18), Gen. Engr., Gen. Elec. Co., 570 Lexington Ave., New York, N. Y.; *for mail*, 154½ Sip Ave., Jersey City, N. J.
SHOUDY, W. A. ('03), Vice-President, '35-'37; Cons. Engr., Orrok, Myers & Shoudy, Associates, 21 E. 40th St.; also Assoc. Prof. M. E., Columbia Univ.
SHULTIS, A. Everard ('24; 33; '35), Sales Engr., Johns-Manville Sales Corp., 22 E. 40th St., New York; *for mail*, 588 Park Ave., Yonkers.
SHUMATE, Frank D. ('18), Specialist, Worthington Pump & Mchy. Corp., 2 Park Ave., New York; *for mail*, 47 Maple Ave., New Rochelle.
SHUMOWSKY, Stanislaw A. (J'34), Asst. Am. Rep., Charge Engrg., Am. Office of Commissariat of Heavy Industries of U. S. S. R., 261—5th Ave.
SICKLES, Eugene C. ('96; '04), Advisory Engr., 15 John St., New York, N. Y.; *for mail*, 256 N. 11th St., Newark, N. J.
SIDLEY, Paul R. ('33; '35), Resident Engr. in U. S. A. for Brown, Boveri & Co., Ltd., of Baden, Switzerland; *for mail*, 19 Rector St., New York, N. Y.
SIEFERT, Geo. C. ('35), Mgr. of Proposition Dept., Combustion Engrg. Co., Inc., 200 Madison Ave.
SIEGER, Eugene K. ('33; '36), Engr., A. B. See Elev. Co., 419—4th Ave., New York; *for mail*, 35-22—90th St., Jackson Heights, L. I.
SIESS, Edw. ('31; '35), Engr., Duplex Ptg. Press Co., Suite 1400, Times Bldg., New York; *for mail*, 88-17 Union Turnpike, Glendale, L. I.
SIEWECK, Carl A. ('31), 4761 Broadway.
SIMONS, Leon (J'36), 50 E. 191st St.
SIMPSON, Colin C., Jr. ('12; '21), Engr. Distribution, Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.
SINGER, Ferdinand L. (J'28), Instr. Engrg., N. Y. Univ., University Heights.
SLAUSON, Harold W. ('08; '23), 1775 Broadway.
SLEE, Norman S. ('09; '18), N. Y. Dist. Sales Mgr., Babcock & Wilcox Co., 85 Liberty St.
SLICHTER, Walter I. ('02; '12), Head Dept. E. E., Columbia Univ., 116th St. & Broadway.
SLIFKA, Martin (J'31), Asst. Secy., Pur. Agt., Parker-Kalon Corp., 200 Varick St.
SLINGMAN, Theo. D., Jr. ('28; '35), Dist. Sales Mgr., Dayton Rubber Mfg. Co., 11 Park Pl.
SLOAT, Benj. C. ('18; '23), Sta. Engrg. Dept., N. Y. Steam Corp., 130 E. 15th St.; *for mail*, 245 Madison Ave.
SMACK, John C. ('30; '35), Asst. Sales Mgr., Indus. Div., S. S. White Dental Mfg. Co., 10 E. 40th St.
SMITH, A. Parker ('87), Pat. Lawyer, 36 W. 44th St.
SMITH, Allen C. ('02), Gen. Wks. Engr., Otis Elev. Co., 260—11th Ave., New York; *for mail*, 33 Morris St., Yonkers.
SMITH, E. Dillon (J'35), Charge Economics & Indus. Admin., Sch. Sci. & Tech., Pratt Inst., Brooklyn; *for mail*, 270 Convent Ave., New York.
SMITH, Earl B. ('32), Prof. M. E., College of City of N. Y., 140th St. & Amsterdam Ave.
SMITH, Edric Brooks ('13; '35), Business Mgr., Rockefeller Inst. of Medical Research, 66th St. & York Ave.
SMITH, Frank H. (A'28), Ch. Engr., Mt. Sinai Hospital, 1 E. 100th St., New York; *for mail*, 85 Bruce Ave., Yonkers.
SMITH, Frank Winthrop ('36), Asst. M. E., Superheater Co., 60 E. 42nd St., New York, N. Y.; *for mail*, 383 Hickory St., Teaneck, N. J.
SMITH, H. Raymond ('16), M. E., Raymond Concrete Pile Co., 140 Cedar St.
SMITH, Harry A. ('29; '35), Engr., Engrg. Specialties Co., Inc., 39 Cortlandt St.
SMITH, Henry S. ('19), Cons. Engr., Union Carbide Co., 30 E. 42nd St.
SMITH, Jas. Jos. (J'36), 59th St. Power House, Interborough Rapid Transit Co.; *for mail*, 14 W. 103rd St.
SMITH, Reginald C. ('26; '35), M. E., Charge Constr., Max B. Miller & Co., Inc., 501—5th Ave.
SMITH, W. Manning ('36), Engr., Charge Design, Phoenix Engrg. Corp., 2 Rector St., New York; *for mail*, 1473 Castleton Ave., Port Richmond, S. I.
SMITH, Wayne Everett ('28), Research Engr., Doherty Research Co., 60 Wall St., New York, N. Y.; *for mail*, 243 Jefferson Ave., Haddonfield, N. J.
SMITHE, Ferdinand L. ('12), Pres., F. L. Smithe Mch. Co., 633 W. 44th St.
SNEATH, Wm. H. ('21), Ch. Engr., Elec. Furnace Products Co., Ltd., 30 E. 42nd St.
SNIDER, Clarence A. ('22), Pres., Sulphur Export Corp., 420 Lexington Ave.
SOMERS, John C. ('27; '35), Gen. Sales Rep., Johns-Manville Corp., 22 E. 40th St., New York; *for mail*, 32-45—81st St., Jackson Heights, L. I.
SOMERS, Wm. E. (J'33), Apprentice Engr., Babcock & Wilcox Co., 19 Rector St.; *for mail*, West Side Y. M. C. A., 5 W. 63d St.
SONDERMAN, Gerhard ('35; '36), M. E., Charge Design, Am. Gas & Elec. Co., 30 Church St., New York; *for mail*, 158 Carlton Terrace, Stewart Manor, L. I.
SOPER, Henry F. ('30), Valspar Corp., 386—4th Ave., New York, N. Y.; *for mail*, 10 Overlook Pk., Montclair, N. J.
SPANGLER, Saml. F. ('20; '25; '35), Sales & Exec. Duties, Chem. Constr. Corp., 30 Rockefeller Plaza, New York; *for mail*, 71 Brewster Rd., Scarsdale.
SPECTOR, B. ('33; '35), 2032 Creston Ave.
SPEIGHT, Herbert ('23), Indus. Engr., Westinghouse Elec. & Mfg. Co., 150 Broadway, New York, N. Y.; *for mail*, 80 Valleywood Rd., Cos Cob, Conn.
SPENCER, Benj. H. ('27), Mech. Designer, Sanderson & Porter, 52 William St., New York, N. Y.; *for mail*, 85 Glendale St., Nutley, N. J.
SPENCER, Clarence G. ('11), Pres., Baker & Spencer, Inc., 17 Battery Pl.
SPERO, Chas. W. (J'33), Engr. Asst., Bd. of Water Supply, 1000 Bronx Park S., New York; *for mail*, 228 Duffield St., Brooklyn.
SPERRY, Clarence E. ('25; '31; '33), Serv. Engr., Detroit Lubricator Co., 40 W. 40th St.
SPERZEL, Jos. M. (J'30), Student Engr., N. Y. Tel. Co., 140 West St., New York; *for mail*, 858 Delamere Pl., Brooklyn.
SPIVAK, Benj. L. ('24; '30; '35), M. E., Charge M. E., Utility Consumers Serv., Inc., 470—4th Ave.; *for mail*, 729 Prospect Ave.
SPORN, Philip ('33), V. P. & Ch. Engr., Am. Gas & Elec. Co., 30 Church St., New York; *for mail*, 157 Beaumont St., Brooklyn.
SPRAGUE, Desmond ('36), 421 Canal St.
SPRAGUE, Theo. S. (J'36), Opera. & Maint., Metro. Life Ins. Co., 1 Madison Ave., New York; *for mail*, 348 Jefferson St., Inwood, L. I.
SPRONG, Severn D. ('12), Pres., Engrg. Products Corp., 39 Cortlandt St.
SPURLING, O. C. ('07), Plant. Engr., West. Elec. Co., Inc., 195 Broadway.
STAFFORD, John W. ('23), Ch. Engr., Suchar Process Corp., 120 Wall St.
STAIGER, Wm. ('23), M. E., Charge Maint., Sheffield Farms Co., 524 W. 57th St., New York; *for mail*, 8715—63d Dr., Elmhurst, L. I.
STAMER, Frank R. ('18; '23; '29), Gen. Supt., Sapolin Co., Inc., 229 E. 42nd St., New York; *for mail*, 32 Beech St., Floral Park, L. I.
STANGLAND, Robt. S. ('16), Ch. Engr., By-Products Recoveries, Inc., 90 West St.
STANHOPE, Hjalmar W. P. (J'29), E. E. Chem. Constr. Corp., Rm. 6170, 30 Rockefeller Plaza.

STAPLES, Horace A. ('03; '16), V. P., Charge Mfg., Phelps Dodge Copper Products Corp., 40 Wall St.
STARK, A. W. ('18), Engr., Bldg., Consltd. Edison Co. of N. Y., Inc., 4 Irving Pl.
STAUB, Morton H. (J'36), Asst. Dist. Engr., Johns-Manville Corp., 22 E. 40th St., New York, N. Y.; *for mail,* 16 Stiles St., Elizabeth, N. J.
STEAD, Frank A. ('24; '29), Pres., Permochart Corp., 295 Madison Ave., New York; *for mail,* 23 Oakwood Ave., Rye.
STEBBINS, Theo. ('03), c/o A. S. M. E., 29 W. 39th St.
STEINBERG, Harry (J'36), 2023 Davidson Ave.
STEINBERG, Louis (J'31), M. E., Products & Tool Design, Metro Mfg. Co., 336 Mountain Rd., Union City, N. J.; *for mail,* 65—2nd Ave., New York, N. Y.
STENGREN, John S. ('28), Assoc. M. E., Valuation, N. Y. State Pub. Serv. Comm., 80 Centre St., New York; *for mail,* 75 Broadway, Rockville Centre, L. I.
STENSON, Chas. J. (J'25), Vent. Designer, N. Y. City Tunnel Authority, 200 Madison Ave.
STERN, Arthur Cecil (J'30), Supt., Wks. Progress Admin., Project 6010, Charge Air Pollution Survey of City of N. Y., 139 Centre St.; *for mail,* 666 West End Ave.
STETSON, Geo. A. ('20; '35), Editor, A. S. M. E., 29 W. 39th St.
STEVENS, John E. ('19; '35), 1060 Forest Ave.
STEWART, Frank Y. (A'30), Exec. V. P., Engrg. Index, Inc., 29 W. 39th St., New York; *for mail,* 35 May St., New Rochelle.
STEWART, S. W. ('21), Pres., Ambursen Constr. Co., Inc., 295 Madison Ave.
STEWART, Thos. O. (J'29), Engrg. Specialities Co., Inc., 39 Cortlandt St., New York; *for mail,* 9615 Shore Rd., Brooklyn.
STIEHL, Harry M. (J'24), Ch. Engr., W. N. Best Corp., 295—5th Ave., New York, N. Y.; *for mail,* 1053 Dearborn Rd., Palisade, N. J.
STILLMAN, Thos. B. ('13; '21; '35), Babcock & Wilcox Co., 85 Liberty St.
STITT, Arthur B. (J'33), Engr., Design, F. H. McGraw & Co., 51 E. 42nd St., New York, N. Y.; *for mail,* 30 Bundy Apts., Middletown, Ohio.
STIX, Lawrence C. (J'11), Treas., S. Oppenheimer & Co., 466 Washington St.
STOLBERG, Emil C. ('17), Gen. Improvement Engr., Am. Car & Fdy. Co., 30 Church St.
STOLL, Clarence G. ('18), V. P., Charge Opera., West. Elec. Co., Inc., 195 Broadway.
STONE, Chas. A. ('14), Chmn., Bd. of Dirs., Stone & Webster, Inc., 90 Broad St.
STONE, Leonard ('19; A'25), Statistician, Office Mgmt., Am. Tel. & Tel. Co., 195 Broadway.
STONE, R. A. ('27; '32; '35), Project Engr., Gen. Chem. Co., 40 Rector St.
STRACHAN, Ben. W. ('28; '35), M. E., Charge Design & Constr., Van Iderstine Co., Long Island City; *for mail,* 501 W. 113th St., New York.
STRANG, Cortland J. ('25; '33), Mech. Dept., N. Y. Times, 233 W. 43rd St.
STRAUSS, Benj. J. ('29; '35), Engr., Am. Can Co., 230 Park Ave., New York; *for mail,* 10929—201st St., Hollis, L. I.
STRICKER, Adam K., Jr. (J'29), President's Staff, Gen. Motors Corp., 57th & Broadway.
STRUCKMANN, Holger, 2nd (J'30), M. E., Lone Star Cement Corp., 342 Madison Ave.
STRUNK, Walter C. ('19; '23), Sales Engr., Westinghouse Elec. & Mfg. Co., 150 Broadway, New York, N. Y.; *for mail,* Parkside Rd., Harrington Park, N. J.
STUBBLEBINE, W. A. ('11), Serv. Engr., Babcock & Wilcox Co., 85 Liberty St.; *for mail,* 12 E. 31st St.
STUDLEY, Gideon, Jr. ('18; '22), Mgr., Steam Div., Westinghouse Elec. & Mfg. Co., 150 Broadway.
STUEBING, Albert F. ('17; '23), R. R. Mech. Engr., U. S. Steel Corp., 71 Broadway.
SULLIVAN, Patrick J. (J'34), Sales Dept., C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn; *for mail,* 356 W. 34th St., New York.
SULLIVAN, Sylvester J. (J'35), Custodian-Engr., Charge Bldg., Bd. of Education, 500 Park Ave., New York; *for mail,* 240-19—136th Ave., Rosedale, L. I.
SUTER, Alfred ('31), 200—5th Ave., New York; *for mail,* 82 Pondfield Rd. W., Bronxville.
SUTTON, Frank ('07), Cons. Engr., 140 Cedar St.
SWANSON, Harry R. ('24; '29; '35), V. P., Charge Sales & Engr., Alco Products, Inc., 30 Church St.
SWANTON, Allen F. ('20; '25; '35), Div. Comm. Supvr., Long Lines Dept., Am. Tel. & Tel. Co., 195 Broadway.
SWINBURNE, Ralph E. ('27; '35), 34 Seaman Ave.
SYMON, Maxwell S. (J'33), Time Study Engr., Emerson Radio & Television Corp., 111—8th Ave.; *for mail,* 47 E. 3d St.
SYSKA, Adolph G. ('18; '33), Partner, Syska & Hennessy, 420 Lexington Ave.
TABER, Geo. H., Jr. ('18; '30), V. P., Charge Mfg., Sinclair Refining Co., 630—5th Ave.
TALBOT, Paul A. ('26), Pat. Atty., Empire State Bldg.
TALMAGE, A. A., Jr. (J'27), Asst. in Budget Dept., Ebasco Services, Inc., 2 Rector St.
TANGERMAN, Elmer J. ('29) Assoc. Editor, Power, McGraw-Hill Publ. Co., Inc., 330 W. 42nd St.
TAPPAN, Chas. O. ('15), Cons. Engr., 39 Broadway.
TAUBE, H. R. ('30), Publicity Dept., Combustion Engrg. Co., Inc., 200 Madison Ave.; *for mail,* 330 E. 52nd St.
TAYLOR, George R. (J'35), Asst. to Wks. Engr., Maint. & Constr., Kirkman & Son, Inc., 215 Water St., Brooklyn; *for mail,* 5 W. 63rd St., New York.
TAYLOR, Henry W. ('36), Cons. Engr., 11 Park Pl.
TEALL, Chas. H. (J'33), Designer, J. O. Ross Engrg. Corp., 350 Madison Ave.
TEAZE, Moses Hay ('21), Partner, H. S. Ferguson & Co., 200—5th Ave., New York, N. Y.; *for mail,* 31 Clarendon Pl., Bloomfield, N. J.
TEICHMANN, Frederick K. (J'29), Asst. Prof. Aero. Engrg., Daniel Guggenheim Sch. of Aero., N. Y. Univ., University Heights.
TELFORD, Marshall H. (J'26), Engr., Freeboard Dept., Am. Bur. of Shipping, 24 Old Slip, New York; *for mail,* 32 Bayberry St., Bronxville.
TENNEY, Ashton M. (A'19), A. M. Tenney Associates, 171 Madison Ave., New York; *for mail,* 15 Oakdale Ave., New Rochelle.
TENNEY, Theo. S. ('10), Cons. Engr., Tenney & Ohmes, 101 Park Ave.
THAYER, Robt. E. ('11; '19), Business Mgr., Railway Mechanical Engineer, 30 Church St.
THEOBALD, Carl D. (J'27), Johnson & Wierk, Cons. Engrs., Grand Central Terminal Bldg.; *for mail,* 730 Riverside Dr.
THOENE, Fred A. ('20; '26; '35), Supt.'s Asst., Consltd. Edison Co. of N. Y., Inc., 501 E. 21st St., New York; *for mail,* 3447—86th St., Jackson Heights, L. I.
THOMAS, Chas. Walter ('88), Cons. Engr., Part Owner, Gen. Dehydration Co., 116 Warren St., New York, N. Y.; *for mail,* 59 Bliss Ave., Tenafly, N. J.
THOMAS, Felix ('14; '26), Pat. Solicitor, Cooper, Kerr & Dunham, 233 Broadway.
THOMAS, Harold D. ('22), V. P., M. E., Charge Design & Maint., Photovend Corp., 30 E. 21st St.
THOMPSON, D. B. ('17; '35), Asst. Engr., N. Y. Cent. R. R., Rm. 848, 466 Lexington Ave.
THOMSEN, Wm. A. V. ('21; '24; '35), Plant Mgr., Halliwell, Inc., 100—6th Ave., New York, N. Y.; *for mail,* 1345 Putnam Ave., Plainfield, N. J.
THOMSON, T. Kennard ('07), Cons. Engr., 32 W. 40th St.
THROCKMORTON, John W. ('28; '34), Alco Products, Inc., 220 E. 42nd St.; *for mail,* 27 W. 67th St.
THUERK, H. C. ('29; '33), Asst. to V. P., Charge Power Sales & Indus. Devel., Utility Mgmt. Corp., 150 Broadway.
TIBBALS, Geo. A. ('97), Retired; 20 E. 76th St.
TIEFERT, Clarence G. (J'36), M. E. Drafting, Designing, Casteel Research Lab., 5757 Faraday Ave.; *for mail,* 342 W. 22nd St.
TIFFT, Thos. D. ('30), Asst. Ch. Engr., Sinclair Refining Co., 45 Nassau St., New York, N. Y.; *for mail,* 728 Crescent Pkwy., Westfield, N. J.
TIGER, Howard L. ('21; '26; '35), V. P., Charge Research & Devel., Permutit Co., 330 W. 42nd St.
TILLEY, John ('14), M. & E. E., Marc Eidlitz & Son, Inc., 100 E. 42nd St.
TILLQUIST, David (J'33), M. E. Inspr., Parks Dept., City of N. Y., Arsenal, Central Park; *for mail,* 686 E. 234th St.
TIMPSON, Willard Q. (J'31), S. S. White Dental Mfg. Co., 10 E. 42nd St., New York, N. Y.; *for mail,* 511 Hillside St., Ridgefield, N. J.
TOBIN, Robt. P. ('09), Tech. Advisor for Lubricants & Lub., Socony-Vacuum Oil Co., Inc., 26 Broadway.
TODE, Arthur M. ('23; '35), Cons. Mar. Engr., 17 Battery Pl., New York; *for mail,* 240 Grassy Sprain Rd., Yonkers.
TOENSFELDT, Kurt ('18), Mgr., Pat. Dept., Combustion Engrg. Co., Inc., 200 Madison Ave.
TOMPKINS, J. Gordon (J'32), Sales Engr., Norma-Hoffman Bearings Corp., 155 E. 44th St., New York; *for mail,* R. F. D. 2, Downing Hill, White Plains.
TOOKER, Leslie E. (J'29), Test Engr., Ford Instrument Co., Inc., Rawson St. & Nelson Ave., Long Island City; *for mail,* 281 E. 205th St., New York.
TORRANCE, Henry ('97; '02), V. P., Treas., M. E. Carbondale Mch. Co., 175 Christopher St.; *for mail,* 112 E. 17th St.
TOUSSAINT, Eugene ('27), Engr., 30 Church St.
TOWER, J. Wallace ('14), Mem. Firm, H. S. Ferguson & Co., Cons. Engrs., Rm. 1303, 200—5th Ave.
TOWERS, Jas. F. ('22), V. P., Ford, Bacon & Davis, Inc., 39 Broadway.
TOWL, Forrest M. ('90), Pres., So. Pipe Line Co., Rm. 2611, 26 Broadway.
TOWN, Frederic E. ('05), Gen. European Mgr., Otis Elev. Co., 260—11th Ave.
TOWNE, Tom (A'95), Box 17, Engineers' Club, 32 W. 40th St.
TOWNER, John Emerson (J'31), 38 W. 93d St.
TOWNSEND, Albert C. ('10; '18; '26), Salesman, B. F. Sturtevant Co., 420 Lexington Ave.; *for mail,* 137 W. 85th St.
TOWNSEND, Norman F. ('31; '35), Ch. Engr., Willcox & Gibbs Sewing Mch. Co., 658 Broadway, New York; *for mail,* 42 Wesley Ave., Port Chester.
TOWSE, Harold R. ('22; '30; '35), Combustion Engrg. Co., Inc., 200 Madison Ave.
TRESCHOW, Michael ('31), M. E., Charge Research & Testing, F. L. Smidth & Co., 225 Broadway, New York, N. Y.; *for mail,* Box 335, Tehachapi, Calif.
TRETHAWAY, J. D. ('28; '35), Sales Engr., Cerro de Pasco Copper Corp., 42 Wall St., New York, N. Y.; *for mail,* 34 Watchung Ave., Montclair, N. J.
TROGER, Geo. F. (J'36), Design Engr., Van Iderstine Co., R. R. & Greenpoint Ave., Long Island City; *for mail,* 650 W. 173rd St., New York.
TROST, Paul A. ('20), Engrg. Exec. with Geo. F. Hardy, 305 Broadway.
TROUNSTINE, Lewis J., Jr. (J'26), Hotel Warwick, 54th St. & 6th Ave.
TULLAR, Irving (J'33), Design Engr., Foster Wheeler Corp., 165 Broadway.
TULLOCH, Wm. Alex ('36), 1947 Broadway.
TURITZ, Marko (J'28), Designer, Combustion Engrg. Co., 200 Madison Ave., New York; *for mail,* 19 Delano Ave., Yonkers.
TURNER, Channing ('16; '25), Office Mgr., Alfol Insulation Co., Inc., Chrysler Bldg.
UDALL, Phillip A. ('18; '35), Pres., Udall & Landan Mfg. Co., Inc., 295 Lafayette St.
UEBELACKER, Chas. F. ('13), Dir., Ford, Bacon & Davis, Inc., 39 Broadway.
UHDE, Wm. (J'36), c/o Bernhard Kuhn, 1824 Weeks Ave.
UHLHORN, Wm. F. (J'31), Jr. Engr., Waterside Sta., N. Y. Edison Co., Inc., 38th St. & 1st Ave., New York, N. Y.; *for mail,* 4847 N. 15th St., Philadelphia, Pa.
ULBERT, August (J'25), Engr., Sales, Alco Valve Co., Inc., 381—4th Ave.
UNDERWOOD, Robt. C. ('25), M. E., Reynolds Research Corp., 65 Broadway, New York; *for mail,* 1368 Hancock St., Brooklyn.
UNKLES, E. H. ('28), Asst. to Pres., Trans-Lux Daylight Picture Screen, 247 Park Ave., New York, N. Y.; *for mail,* 35 Hudson Pl., Weehawken, N. J.
UPDIKE, David M. ('20), Supt. Bldgs. & Grounds, Columbia Univ.
UPSON, Maxwell M. ('01; '07; '12), Pres., Raymond Concrete Pile Co., 140 Cedar St.
VALENTINE, C. Irving (J'33), 514 W. 36th St.
VALMOS, L. L. (J'30), 591 W. 178th St.
VAN BOMEL, Leroy A. ('18), Pres., Sheffield Farms Co., also V. P., Natl. Dairy Prod. Corp., 524 W. 57th St.
VAN BRUNT, John ('14), V. P., Charge Engrg., Combustion Engrg. Co., Inc., 200 Madison Ave.
VAN BUSKIRK, Geo. L. ('21; '25; '35), Routine Engr., Motive Power Dept., Interborough Rapid Transit Co., 600 W. 59th St.; *for mail,* 21 W. 123rd St.
VANDERBILT, Cornelius ('99; 'A'01), 32 Nassau St.
VAN DEVENTER, Frank M. ('18; '24; '26), Walworth Co., 60 E. 42d St.
VAN FLEET, Herman ('18), V. P. & Operating Manager, Air Reduction Co., Inc., 60 E. 42nd St.
VAN HAMONT, Edw. F. (J'34), Engr., Indus. Dept., W. R. Grace & Co., 7 Hanover Sq.; *for mail,* 333 E. 79th St.
VAN RIPER, Francis H. ('21; '35), Surveyor, Am. Bur. of Shipping & Aircraft, 24 Old Slip, New York, N. Y.; *for mail,* 408—16th St., Union City, N. J.
VAN VALKENBURGH, Merritt ('15; '22; '35), V. P., W. B. Richards & Co., Inc., 545—5th Ave., New York; *for mail,* Highmount Ave., Upper Nyack.

VEAL, C. B. ('07; '12), Research Mgr. & Asst. Gen. Mgr., Soc. Automotive Engrs., Inc., 29 W. 39th St., New York; *for mail*, 246 Locust Ave., Freeport, L. I.
VENDELEERS, A. F. (J'36), 72 W. 82nd St.
VISCARDI, John E. (J'33), Research Assoc. in M. E., Engrg. Sch., Columbia Univ.
VITTUCCI, Rocco V. (J'36), Engr., Heat Balance, Power Plant Ext., Am. Gas & Elec. Co., 30 Church St.
von der HEYDE, George ('29; '35), Partner, A. Wilson & Co., 136 Liberty St., New York; *for mail*, 23 Sutton Pl., Verona, N. J.
von PHUL, Wm. ('07), Pres., Ford, Bacon & Davis, Inc., 39 Broadway.
von VITTINGHOFF, Hans ('16), Cons. Engr., Stone & Webster Engrg. Corp., 90 Broad St.
VOORHEES, John R. ('16; '19), M. E., Turner Constr. Co., 420 Lexington Ave., New York, N. Y.; *for mail*, 26 Woodcrest Ave., Millburn, N. J.
VOORHEES, Stephen F. ('23), Sr. Partner, Voorhees, Gmelin & Walker, 101 Park Ave.
VOSHALL, Leroy B. (J'31), Automotive Engr., Tex. Co., 135 E. 42nd St., New York; *for mail*, 401 Bronxville Rd., Bronxville.
VOSS, J. H. H. ('29), Pres., Treas., J. H. H. Voss, Inc., 408 Concord Ave.
WAAGE, John J. ('29; '35), Factory Mgr., Globe Slicing Mch. Co., Inc., 450 Whitlock Ave.
WAALAND, Thos. (J'33), Asst. Prod. Supt., Sheffield Farms Co., Inc., 524 W. 57th St., New York; *for mail*, 546—77th St., Brooklyn.
WADLEIGH, Geo. R. ('07), Mgr. Engrg. Dept., W. Va. Pulp & Paper Co., 230 Park Ave.
WADSWORTH, Geo. R. ('10), Asst. Commissioner, Correction, State of N. Y., 155 Worth St.
WAER, Robt. L. (J'26), V. P., Gen. Mgr., Crawford Engrg. Co., Inc., 295 Madison Ave.
WAGONER, Philip D. ('14), Pres., Underwood Elliott Fisher Co., 1 Park Ave.
WAIT, Justin F. ('33), Cons. Engr., 1520 Jesup Ave.
WALDRON, Fred'k A. ('90; '96), Cons. Engr., 40 Exchange Pl.
WALHOVIC, John J. (J'31), Clerk, Richard G. Babbage, Rm. 908, 111 Broadway, New York; *for mail*, 345 Glenmore Ave., Brooklyn.
WALKER, Jas. B., Jr. (J'32), Draftsman, Engrg. Design, Babcock & Wilcox Co., 19 Rector St.
WALLACE, Henry B., Jr. (J'35), Foster Wheeler Corp., 165 Broadway.
WALLENDORF, Chas. R. (J'22), Dist. Mgr. of Sales, Crandall Packing Co., 99 Hudson St., New York, N. Y.; *for mail*, 138 Kildare Rd., Garden City, L. I.
WALSH, Col. Jas. L. ('35), University Club, 1 W. 54th St.
WALTER, F. Lincoln (J'33), Mar. Office of Am., 116 John St., New York, N. Y.; *for mail*, 324 Harrison Ave., Hasbrouck Heights, N. J.
WALTHER, Paul H. ('20), Pres., Am. Chimney Corp., 147—4th Ave., New York, N. Y.; *for mail*, 1020 Abbott Blvd., Palisade, N. J.
WANDEL, Carleton ('14; '18; '35), Salesman, Farrell-Cheek Steel Fdy. Co., 136 Liberty St., New York, N. Y.; *for mail*, 3 Reid Ave., Babylon, L. I.
WARD, Roswell H. (J'27), 56—7th Ave.
WARE, John S. (J'27), Sales Engr., Natl. Sugar Refining Co. of N. J., 129 Front St.; *for mail*, 51 E. 90th St.
WARNER, Edw. P. ('17; '25; '28), Editor, Aviation, McGraw-Hill Publ. Co., Inc., 330 W. 42nd St.
WARNER, Saml. T. ('19), 365 West End Ave.
WARNKE, Herbert R. (J'29), Engr., Control Instrument Co., Inc., 423 W. 126th St.
WASSER, Reuben ('28; '34; 35), Power Plant Testing, Pub. Serv. of N. J., 396 Clinton Ave., Irvington, N. J.; *for mail*, 260 Ft. Washington Ave., New York, N. Y.
WASSMER, Geo. W. (J'32), Sales Engr., Harnischfeger Sales Corp., New York, N. Y.; *for mail*, 222—34th St., Woodcliff, N. J.
WASSON, Robt. A. (J'28), Branch Sales Mgr., Clarage Fan Co., 40 W. 40th St., New York; *for mail*, 15 Willow St., Brooklyn.
WATER, Robt. H. ('19; '35), 75 West St., New York, N. Y.; *for mail*, 89 Maplewood Ave., Maplewood, N. J.
WATERS, Wm. L. ('09), Cons. Engr., 150 Nassau St.
WATKINSON, R. M. (J'35), Engrg. Draftsman, Gibbs & Cox, Inc., 1 Broadway, New York; *for mail*, 941 E. 37th St., Brooklyn.
WATTS, Robt. L. ('18), Gen. Mgr., Lubriplate Div., Fiske Bros. Refining Co., 24 State St., New York, N. Y.; *for mail*, 107 Rocky Wood Rd., Manhasset, L. I.
WEBB, Clifford L. ('16; '21), Cons. Engr., Gen. Milk Co., 19 Rector St.
WEBER, Nicholas (J'33), Ch. Engr., C. H. Leach Co., 117 Liberty St., New York, N. Y.; *for mail*, 15 Tessen St., Teaneck, N. J.
WEBSTER, Danl. T., Jr. (J'32), Engr., Clyde R. Place, 420 Lexington Ave.; *for mail*, 360 E. 55th St.
WEBSTER, Hosea, Jr. ('30), 22 E. 42nd St.
WEBSTER, John D. ('22; '35), M. E., Phoenix Engrg. Corp., 2 Rector St., New York, N. Y.; *for mail*, 208 Tenafly Rd., Englewood, N. J.
WEGG, David S. ('09; '14; '21), Cons. Engr., 687 Lexington Ave.
WEICHERT, Arnold E. ('07), Engr., Combustion Engrg. Co., Inc., 200 Madison Ave., New York, N. Y.; *for mail*, 54 Cleveland Terrace, Bloomfield, N. J.
WEIGEL, A. C. ('14; '19), Combustion Engrg. Co., Inc., 200 Madison Ave.
WEILL, Melville K. ('21), Business Counselor, 21 E. 40th St.; *for mail*, 225 W. 86th St.
WEINBAUM, Rubin (J'36), Engr., 945 Aldus St.
WEINBERG, Herbert L. ('24; '27; '35), Asst. Engr., N. Y. Cent. R. R. Co., Rm. 1448, 466 Lexington Ave.
WEINHOLD, Julius F. ('25; '31; '35), Constr. Engr., Charge Pur. & Constr., East. Div., Alphons Custodis Chimney Constr. Co., 135 William St.
WEINSTEIN, Alex. ('30), Cons. Indus. Engr., 120 Broadway.
WEISS, Jos. R. ('27; '36), Instr., Sch. of Tech., College of City of N. Y., 140th St. & Amsterdam Ave.
WEISSELBERG, Arnold ('26; '35), Cons. Engr., 1071—6th Ave.
WEISZ, Martin ('21; '27; '35), 1243 Webster Ave.
WELCH, Wm., Jr. (J'26), Asst. M. E., Interborough Rapid Transit Co., 600 W. 59th St.
WELDEN, Fay D. (J'31), Serv. Engr., Valve Pilot Corp., 230 Park Ave., New York; *for mail*, 74 Chippewa Rd., Tuckahoe.
WELLING, Lindsay H. ('16; '24; '35), Jackson & Curtis, 115 Broadway, New York; *for mail*, 3 Norwood Rd., Scarsdale.
WELLINGTON, C. Oliver (A'21), Partner, McKinsey, Wellington & Co., 52 Wall St.
WELLS, E. H., Jr. (J'33), Ch. Engr., Transportation Dept., Johns-Manville Corp., 22 E. 40th St.
WENDLAND, Chas. F., Sr. ('14), Ch. Engr., Empire State, Inc., 350—5th Ave., New York; *for mail*, 1194 Brooklyn Ave., Brooklyn.
WERTMAN, David (J'36), 256 E. 170th St.
WEST, John W., Jr. (J'19), Secy., Commercial Section, Am. Gas Assn., 420 Lexington Ave.
WESTERGAARD, Viggo ('26; '32; '35), M. E., Dept. of Sanitation, City of N. Y., 125 Worth St.
WETTER, Pierce T. ('27; '30; '35), V. P., Am. Cutting Alloys, Inc. & Am. Electro Metal Corp., 500—5th Ave.
WHEATLEY, John G. ('29), Supt., Engrg. Dept., Eagle, Globe & Royal Indemnity Co., 150 William St.
WHEELER, Hobart W. R. ('30), Sales Engr., Griscom-Russell Co., 285 Madison Ave.
WHIPPLE, Thos. T. (J'29), Engr., Charge Design, Lummus Co., 50 Church St.; *for mail*, 960 Grand Concourse.
WHISLER, Forbes D. (J'35), Apprentice M. E., Gen. Chem. Co., 40 Rector St., New York; *for mail*, 1036 Hollywood Ave., Far Rockaway, L. I.
WHITAKER, Chas. H. (J'23), Gen. Mfg. Dept., Continental Can Co., 100 E. 42nd St.
WHITAKER, Ebenezer ('23), Ch. Engr., N. Y. Athletic Club, 180 Central Park, S.
WHITAKER, Harry E. ('18; '35), Firm Engr., Ford, Bacon & Davis, Inc., 39 Broadway.
WHITE, John Wm., Jr. (J'28), Sales & Estimating, Serv. Dept., Otis Elev. Co., 11th Ave. & 26th St., New York, N. Y.; *for mail*, 286 Oakwood Ave., Orange, N. J.
WHITE, Philip S. ('28; '35), Staff Engr., Geo. S. May Co., 122 E. 42nd St.; *for mail*, 506 Ft. Washington Ave.
WHITE, Walter H. (J'30), Lub. Engr., Stand. Oil Co. of N. J., 26 Broadway, New York, N. Y.; *for mail*, 978 Potter Ave., Townley, Elizabeth, N. J.
WHITEFORD, Alexander W. ('21), Engr., Charge Railroad Sales, Haynes-Stellite Co., 30 E. 42nd St.
WHITEHEAD, Herbert G. (J'36), Ft. Schuyler.
WHITFORD, Robt. (J'32), Library Asst., Library of College of City of N. Y., 139th St. & Convent Ave.; *for mail*, 100 Hamilton Pl.
WHITNEY, H. LeRoy ('22), Dir., Ch. Engr. Piping Vessel Div., M. W. Kellogg Co., Inc., 225 Broadway.
WHITNEY, Morgan M. (J'23), Griscom-Russell Co., 285 Madison Ave.
WHITNEY, Wm. O. ('19; '35), Sales Engr., Dairy & Icecream Mchy., 76—9th Ave., New York, N. Y.; *for mail*, 925 W. 7th St., Plainfield, N. J.
WHITSIT, Lyle A. ('22), Asst. Hyd. Engr., Phœnix Engrg. Corp., 2 Rector St.
WHITTIER, C. R. ('09), Sanderson & Porter, 52 William St.
WIBLING, Seth E. (J'34), Asst., H. Wibling Tool & Mfg. Co., 116 Walker St., New York; *for mail*, 375 Lincoln Pl., Brooklyn.
WICKENDEN, Thos. H. ('28), Asst. Mgr., Devel. & Research, Internatl. Nickel Co., Inc., 67 Wall St.
WIESE, O. H. ('16; '20), Sr. Engr., Merchant Fleet Corp., 45 Broadway, New York; *for mail*, 8448—85th Ave., Woodhaven, L. I.
WILCOX, Harold C. ('24; '35), Assoc. Mech. Editor, Simmons-Boardman Publ. Co., 30 Church St.
WILCOXSON, Leslie S. (J'26), Exec. Asst., Engrg., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail*, 419 Arden Court, Ridgewood, N. J.
WILEY, Wm. O. (A'25), Pres., John Wiley & Sons, Inc., 440—4th Ave.
WILKENS, John A. (A'38), V. P., Treas., Chas. Francis Press, 461—8th Ave., New York; *for mail*, 358 Crown St., Brooklyn.
WILLARD, John A. ('17; '21), Partner, Hopf, Kent, Willard & Co., 500—5th Ave.
WILLARD, Leigh ('07; '10), Pres., Semet-Solvay Co., 61 Broadway.
WILLIAMS, David T. ('20), Asst. to V. P., Charge Engrg., Am. Loco Co., 30 Church St.
WILLIAMS, Ernest ('34), Mgr., Clyde R. Place, 420 Lexington Ave.
WILLIAMS, Frank S. G. ('34; '35), Dist. Mgr., Taylor Forge & Pipe Wks., 50 Church St.
WILLIAMS, John Howell ('20), Cons. Mgmt. Engr., 150 E. 35th St.
WILLIAMS, Roger S. ('24; '35), 120 Wall St.
WILLIAMS, Saml. C. ('17; '26), Dir. of Research, Scudder, Stevens & Clark, 1 Wall St.
WILLIAMS, Saml. L. (J'24), Dist. Engr., Westinghouse Air Brake Co., 350—5th Ave.
WILLOUGHBY, Victor R. ('21), Gen. M. E., Am. Car & Fdy. Co., 30 Church St.
WILSON, Chester W. ('18), Cons. M. E., Am. Smelting & Refining Co., 120 Broadway.
WILSON, Geo. P. ('27; '31; '35), Draftsman, 5th Ave. Coach Co., 605 W. 132nd St.; *for mail*, 2500 Webb Ave.
WILSON, Jacob D. ('03; '14), Pres. & Treas., Am. Elev. & Mch. Corp., 113-117 Cedar St., New York; *for mail*, 1167 E. 19th St., Brooklyn.
WILSON, John Amerman, Jr. ('23; '33; '35), Engr., Lancaster Iron Wks., Inc., 120 E. 42nd St., New York, N. Y.; *for mail*, Highwood Ave., Tenafly, N. J.
WILSON, Oliver W. ('17; '25; '35), Combustion Engrg. Co., Inc., 200 Madison Ave., New York, N. Y.; *for mail*, 26 Stockton Pl., E. Orange, N. J.
WIMMER, L. H. (J'28), 1729 Davidson Ave.
WING, Wm. N. ('23; '35), Supvrg. Engr., London Guarantee & Accident Co., 55—5th Ave., New York; *for mail*, 600 E. 7th St., Brooklyn.
WINSLOW, Pearson ('21; '35), V. P., Bonbright & Co., Inc., 25 Nassau St.
WINTERHALTER, Frederick (J'35), Indus. Engr., Thomas & Betts Mfg. Co., 36 Butler Ave., Elizabeth, N. J.; *for mail*, 64 W. 192nd St., New York, N. Y.
WINTHER, Geo. S. ('23), Lone Star Cement Corp., 342 Madison Ave.
WINTZER, R. C. (J'29), Engrg. Dept., Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.; *for mail*, 401 South Ave., Westfield, N. J.
WISE, Roy T. ('36), Cons. Engr., Union Twist Drill Co., Athol, Mass.; *for mail*, 340 W. 57th St., New York, N. Y.
WISNER, Henry G., Jr. ('22; '35), Combustion Engrg. Co., Inc., 200 Madison Ave., New York; *for mail*, 43 Park Ave., Bronxville.
WITTMAN, Lawrence (J'33), Gen. Novelty Co., 330 W. 38th St.; *for mail*, 161 W. 75th St.
WOEHR, Frank G. (J'31), Teacher, Aviation Mechanics, Manhattan High Sch. of Aviation Trades, 220 E. 64th St.; *for mail*, 95 W. 183rd St.
WOERWAG, C. A. ('20; '35), Engr., Charge Exports, Link-Belt Co., 233 Broadway.
WOHLBERG, Geo. (J'32), Mech. Designer, R. Hoe & Co., Inc., 138th St. at East River; *for mail*, 87 Vermilyea Ave.
WOHLERS, Chas. ('22), Engr., Matl. Dept., Alco Products, Inc., 30 Church St., New York; *for mail*, 100-20—205th Pl., Hollis, L. I.
WOHLERS, Karl E. (J'28), Asst. Engr., N. Y. Tel. Co., Rm. 2126, 140 West St.
WOLF, Arnold M. (J'34), Devel. Engr., Am. Radiator Co., 40 W. 40th St., New York; *for mail*, 1670—52nd St., Brooklyn.
WOLF, Irwin (J'22), Prod. Mgr., Noma Elec. Corp., 524 Broadway.
WOLF, Oscar ('31), Asst. Ch. Engr., Tex. Co., 135 E. 42nd St.
WOLL, I. Edw. (J'35), Warren Hall, 404 W. 115th St.
WOLLHEIM, Walter E. ('17; '20), Mgr., Indus. Div., Nathan Mfg. Co., 416 E. 106th St.
WOOD, Benj. F. ('97; '07), V. P., Stevens & Wood, Inc., 30 Broad St.

WOOD, Harry C. (A'35), Sr. Acct., Loomis, Suffern & Fernald, 80 Broad St., New York, N. Y.; *for mail*, 937 Stelle Ave., Plainfield N. J.
WOOD, Jos. Kaye ('23; '35), M. E. for Genespring Hanger, Grinnell Co., Inc., Graybar Bldg.
WOOD, Richard S. (J'30), Designer, Babcock & Wilcox Co., 19 Rector St.
WOOD, Roderick A. (J'36), M. E., Asst. Tech. & Trade Information, Fuèloil Journal, 420 Madison Ave., New York; *for mail*, 482 Bard Ave., Staten Island.
WOODARD, W. E., ('15), V. P., Charge Design, Lima Locomotive W ., Inc., 60 E. 42nd St.
WOODS, Geo. R. ('16; '25), Mgr., R. S. Stokvis & Sons, Inc., 17 Battery Pl., New York, N. Y.; *for mail*, Gatewood St., Morristown, N. J.
WOOLFSON, Harris D. ('24; '26; '35), M. E., 1307 Merriam Ave.
WOOLLEY, Harold O. ('09; '15; '35), Asst. Ch. Engr., Steam Div., Foster Wheeler Corp., 165 Broadway.
WOOLLEY, Paul O. (J'24), Asst. Engr., Adlanco X-Ray Corp., 54 Lafayette St., New York; *for mail*, 193-10—42nd Ave., Auburndale, L. I.
WRAITH, Wm. ('03), Exec. V. P., Andes Copper Min. Co., 25 Broadway.
WRIGHT, L. Kay ('28), Refrig. Instr., Y. M. C. A. Trade & Tech. Sch., 13 E. 63rd St.; *for mail*, 5 W. 63rd St., Box 527.
WRIGHT, Paul D. ('17; '31; '35), 219 E. 238th St.
WRIGHT, Roy V. ('07; F'36), Manager, '22-'25; Vice-President, '25-'27; President, '31; V. P. & Secy., Simmons-Boardman Publ. Co., 30 Church St., New York, N. Y.; *for mail*, 398 N. Walnut St., East Orange, N. J.
WRIGHT, Theo. Paul ('28), Curtiss Wright Corp., RCA Bldg., 30 Rockefeller Plaza.
WRIGHT, Wm. H. ('17), V. P., Semet-Solvay Engrg. Corp., 40 Rector St.
WUEST, Louis L. ('36), Designing Engr., Gries Reproducer Corp., 463 E. 133rd St.; *for mail*, 2953 Lawton Ave.
WURSTER, Wm. F. ('21; '35), Sales Engr., DeWolf Furnace Corp., 90 West St.
WYBURN, Wilfred ('30; '35), Engr., Charge Constr., Tonawanda Div. of Robert Gair Co., New York; *for mail*, 309 Goundry St., N. Tonawanda.
WYNKOOP, N. O. ('30), Adv. Mgr., Power, McGraw-Hill Publ. Co., Inc., 330 W. 42nd St.
YAMAMOTO, T. ('35; '35), Mitsubishi Shaji Co., 120 Broadway.
YANAGIHARA, Capt. H. ('35), Ch. of Office, Japanese Naval Inspc. Office, 1 Madison Ave.
YOCOM, Luke F., Jr. (J'32), Engrg. Asst., Opera. Dept., N. Y. Edison Co., Inc., 415 East 40th St.
YOUNG, C. Higbie ('36), Prof. Mch. Design Dept., Cooper Union, 7th St. at 3rd Ave.
YOUNG, D. L. ('33), Design Engr., Percival R. Moses, Cons. Engr., 570 Lexington Ave.; *for mail*, 1184 Cromwell Ave.
YULKE, Saml. G. (J'35), 1323 Bronx River Ave.
ZACHERT, Arthur R. ('10; '15), Engr., Koppers Co., 16 Court St., Brooklyn; *for mail*, The Shelton, 49th & Lexington Ave., New York.
ZACK, Eugene T. (J'29), Asst. Foreman, N. Y. Cent. R. R., Rm. 1428, 466 Lexington Ave., New York; *for mail*, 191 Benson St., Albany.
ZADEMACH, Erich R. ('20), V. P., Gen. Mgr., Metalwash Mchy. Co., Inc., 117 E. 24th St., New York, N. Y.; *for mail*, 812 Stanton Ave., Elizabeth, N. J.
ZAFFARANO, V. M. (J'32), Asst. Testing Engr., N. Y. Edison Co., Inc., 134th St. & Locust Ave., New York; *for mail*, 35-42—73rd St., Jackson Heights, L. I.
ZALKIND, Albert M. (J'35), 1231 Fulton Ave.
ZAP, Herman (J'34), 880 E. 180th St.
ZAUNMILLER, E. W. (J'32), Charge Special Design, Fidelity & Casualty Co., 80 Maiden Lane.
ZIEGLER, John Wm. ('30; '35), Ch. Engr., Bur. Design & Engrg., John Wanamaker, Broadway & 9th St., New York; *for mail*, 133 Wickham Rd., Garden City, L. I.
ZOLL, Stanley W. ('26; '30; '35), Supt., Metro. Iron Fdy., 890 Metropolitan Ave., Brooklyn; *for mail*, 111 W. 16th St., New York.
ZOUCK, Geo. H. ('14; '26), M. E., Franklin Ry. Supply Co., Inc., 60 E. 42nd St., New York, N. Y.; *for mail*, c/o Balmar Corp., Woodberry, Baltimore, Md.
ZSUFFA, Leslie F. (J'32), Asst. to Treas., United Parcel Serv., 331 E. 38th St., New York; *for mail*, 6103—37th Ave., Woodside, L. I.

NIAGARA FALLS, Buffalo Section

ABENDSCHEIN, Edw. J. (J'35), Draftsman, Chisholm-Ryder Co., Highland Ave.; *for mail*, 1327 Pierce Ave.
BAGLEY, Glen D. ('18; '35), Research Engr., Union Carbide & Carbon Research Labs., Royal Ave.
BAILEY, A. Tanner, Jr. (J'34), Draftsman, E. I. du Pont de Nemours & Co., Chemical Rd.; *for mail*, Jefferson Apts.
BAILEY, Bruce L. (J'34), Devel. Lab., Norton Co., Chippawa, Ont., Can.; *home address*, 568 Third St., Niagara Falls, N. Y.
BELLEGIA, Faust (J'35), Draftsman, Hooker Electrochem. Co.; *for mail*, 423—19th St.
CALL, Leroy J. ('21), Constr. Engr., Plant Layout & Design, Carborundum Co., Buffalo Ave.
EGBERT, Chas. C. ('06), 404 Jefferson Ave.
FEW, E. Liddon ('34), Engr., Charge Design, Carborundum Co., Buffalo Ave.; *for mail*, 102 Niagara St.
FISH, J. Arthur ('30), Constr. Engr., E. I. du Pont de Nemours & Co., Buffalo Ave.; *for mail*, 216 79th St.
GIBB, Jos. F. (J'36), Draftsman, E. I. du Pont de Nemours & Co.; *for mail*, 2451 Linwood Ave.
GOODRICH, Chas. W. McK. ('19; '24; '29), M. E., Charge Equip. Design, Carborundum Co.; *for mail*, 2488 Pierce Ave.
GRIFFIN, Jas. W. (J'36), Am. Sales Book Co., Inc., Highland Ave.
HYDE, Tom B. ('21), Engr., Natl. Carbon Co., Inc., 3625 Highland Ave.
JENKINS, Schuyler V. (J'34), Asst. Project Engr., R. & H. Chems. Dept., E. I. du Pont de Nemours & Co.; *for mail*, 732—8th St.
JOHNSTON, Edwin G. (J'34), 1917 Lockport St.
JOHNSTON, Laurence C. (J'31), Asst. to Supt. of Personnel, Kimberly Clark Co., Packard Rd.; *for mail*, 1917 Lockport St.
KARRE, Wm. A. ('23; '32), Asst. Engr., Mathieson Alkali Wks., Inc., Buffalo Ave.; *for mail*, 2246 Pierce Ave.
LIDBURY, F. Austin ('17), Pres. & Gen. Mgr., Oldbury Electro-Chem. Co., Buffalo Ave.
LYSTER, Thos. L. B. ('15), Cons. Engr., Charge Sales Serv. & New Constr., Hooker Electrochem. Co.; *for mail*, 127 Buffalo Ave.
MITCHELL, W. H. ('13; '35), M. E., Design & Maint., Buffalo, Niagara & East. Power Corp., Elec. Bldg., Buffalo; *for mail*, 536—12th St., Niagara Falls.
NAYLOR, Jas. W. ('36), Designing Engr., Bldgs. & Equip., Niacet Chems. Corp., 47th & Pine Ave.; *for mail*, 1636 South Ave.
NEWTON, Evans Kendrick ('30), Plant Engr., Charge Constr. & Maint., Hooker Electrochem. Co.; *for mail*, 1837 Niagara Ave.
NOBLE, Everett W. (J'28), Indus. Engr., Charge Time Study, Am. Sales Book Co., Inc., Highland Ave.; *for mail*, 917—87th St.
PETROE, Gregory A. (J'22), Devel. Engr., Mathieson Alkali Wks., Inc., 2400 Buffalo Ave.; *for mail*, 4640 Terrace Dr.
REITZ, Edw. J. (J'26), Engr., Maint. Dept., Carborundum Co., Buffalo Ave.; *for mail*, 210—84th St.
RICHMOND, Harold A. ('98; '21), Treas., Gen. Mgr., Gen. Abrasive Co., College Ave.
ROBERT, Philip (J'34), Time Study Engr., Am. Sales Book Co., Inc.
ROSE, Carl Grant (J'31), Research Engr., Carborundum Co.; *for mail*, R. F. D. 1.
RUE, John D. ('30), 3061 Dorchester Rd.
SHEPARD, Geo. R. ('14), Mgr. Commercial Dept., Niagara Falls Power Co.
STOWELL, Howard E. ('14; '21), Engr., Charge Design, Carborundum Co.
STUART, Kenneth E. ('19), Research Engr. & Pat. Atty., Hooker Electrochem. Co.
THOMPSON, Theo. E. ('30; '34; '35), Asst. Power Engr., R. & H. Chems. Dept.; E. I. du Pont de Nemours & Co.; *for mail*, 1256—87th St.
WEITZMANN, Earl J. ('32; '35), Charge Maint., Niacet Chems. Corp., Pine Ave.; *for mail*, 1635 Ontario Ave.

NORTHPORT, L. I., Metropolitan Section

CARLSON, Albert R. (J'33), Engrg. Dept. (Metal Shop), Metro. Life Inc. Co., 1 Madison Ave., New York; *for mail*, Doris Ave., Northport, L. I.
HUSSEY, Wm. E. ('04), Scudder Ave.
MARTIN, Geo. E. (J'29), Draftsman, L. I. Lighting Co., Woodbine Ave., Northport; *for mail*, Woodlawn Ave., St. James, L. I.

NORTH ROSLYN, L. I., Metropolitan Section

POTOPINSKY, Michael (J'33).

NORTH TARRYTOWN, Metropolitan Section

O'CALLAGHAN, F. T. (J'32), Indus. Engr., Fisher Body Co., N. Tarrytown; *for mail*, 19 S. Broadway, Tarrytown.

NORTH TONAWANDA, Buffalo Section

BOWEN, Percy P. ('31), V. P., Plant Mgr., Becker, Moore & Co., Inc.; *for mail*, 19 Pine Woods Dr.
GYSLING, Manuel H. ('30), Ch. Engr., Am. & Can. Dist. Steam Co.; *for mail*, 190 Christiana St.
KLOSSON, M. M. ('28), Ch. Engr., Buffalo Pumps, Inc.
NYE, Robt. G. ('12), Factory Mgr., Dir., Buffalo Pumps, Inc., N. Tonawanda; *for mail*, 86 W. Oakwood Pl., Buffalo.

NORWICH

COPLEY, LeRoy B. (J'27), Plant Engr., Norwich Pharmacal Co.

NUNDA

LUNDBYE, Axel E. ('30; '31), Ch. Engr., Foote Co., Inc.

NYACK, Metropolitan Section

GUNTHER, Chas. O. ('00; '05; '19), Prof. Math., Stevens Inst. of Tech., also Cons. Engr., P. O. Box 822, Hoboken, N. J.; *home address*, Grand View-on-Hudson, Nyack, N. Y.
KLEP, Martin C. ('30; '35), Mech. Designer, N. Y. Edison Co., Inc., 4 Irving Pl., New York; *for mail*, 47 S. Mill St., Nyack.

OGDENSBURG

BROWN, Wm. Clinton ('96), Mgr., Stumpf Una-Flow Engine Co., 331 Ford St., Ogdensburg, N. Y.; *for mail*, Prescott, Ont., Can.
SKELLY, John F. ('22; '23; '35), Constr. & Engr., John F. Skelly, 303 Catherine St.

OLEAN

BEARDSLEY, Edw. G. (J'28), Engr., Clark Bros. Co.; *for mail*, R. D. 1.
BJORNSSON, Carl A. ('15), Diesel M. E., Clark Bros. Co., Olean; *for mail*, 30 Chestnut St., Wellsville.
LANGNER, Fred'k W. ('27; '33; '35), Asst. to Ch. Engr. of Refinery, Socony-Vacuum Oil Co., Inc., Buffalo St.; *for mail*, 1107 W. State St.

ONEIDA, Syracuse Section

KELLER, Martin W. (A'19), Asst. Gen. Wks. Mgr., Oneida, Ltd.
MARCY, Lyle B. ('31), Factory Mgr., Internatl. Silver Co.; *for mail*, Kenwood Sta.
NOYES, Richard W. (J'28), Kenwood Sta.

ORCHARD PARK, Buffalo Section

STARKE, Wm. W. (J'27), Power Engr., Natl. Aniline & Chem. Co., 351 Abbott Rd., Buffalo; *for mail*, 210 W. Quaker St., Orchard Park.

OSSINING, Metropolitan Section

FAWCETT, Howard N. (J'33), Devel. Engr., Cambridge Instrument Co., Inc., 73 Spring St.; *for mail*, 164 Main St.
OCHS, Sidney A. (J'25), M. E., Hudson Wire Co., Ossining; *for mail*, 1030 Nelson Ave., New York.
PACKARD, Horace N. ('11; '19), V. P., Charge Mfg., Cambridge Instrument Co., Inc., 73 Spring St.
PRITCHARD, Randolph Henry ('33), 29 Maurice Ave.

OSWEGO, Syracuse Section

HALLOCK, Homan F. ('10; '16; '30), Cons. Engr., Diamond Match Co.; *for mail*, 28 Montcalm St.
LYONS, Herbert R. ('29; '35), Asst. to M. E., Diamond Match Co.

OZONE PARK, L. I., Metropolitan Section

JEWELL, Chas. W. ('93), 9520 Woodhaven Blvd.
NARDIN, Celestin F. ('23; '35), Pres. & Ch. Engr., Nardin Engrg. Co., 105-39—93rd St.; *for mail*, 105-52—89th St.

PAINTED POST, Ithaca Section

CARPENTER, Allan O. (A'09), Ch. Engr., Painted Post Plant, Ingersoll-Rand Co., Painted Post; *for mail*, 32 E. 3rd St., Corning.
MURPHY, Eugene F., Jr. (J'35), Engrg. Dept., Research & Exper., Ingersoll-Rand Co.; *for mail*, Imperial Club.
WICKERSHAM, Nathan R. ('07), Gen. Supt., Ingersoll-Rand Co., Painted Post; *for mail*, 106 E. 5th St., Corning.

PALMYRA, Rochester Section

HAMILTON, Russell I. (J'27), Asst. Mgr., Garlock Packing Co.
HUBBARD, Cecil R. ('27), V. P., Charge Prod., Garlock Packing Co., 402 Main St.

PATCHOGUE, L. I., Metropolitan Section

FUHRMANN, Frank A. (J'33), 229 Bay Ave.

PEARL RIVER, Metropolitan Section

EISERMAN, Fred'k J. ('29), Mch. Design Engr., Dexter Folder Co.; *for mail*, Box 862, Ridge St.
GRIMM, Adolph ('21; '25), M. E., Charge Spec. Mch. Design, Dexter Folder Co.; *for mail*, P. O. Box 574.
McELROY, John H. ('29), Dexter Folder Co.; *for mail*, Box 857.
YEO, Edw. J. (J'27), Mch. Designer, Dexter Folder Co.; *for mail*, 94 Cedar Ave.

PEEKSKILL, Metropolitan Section

BUNZEL, E. ('16), Ch. Draftsman, Stand. Brands, Inc., Charles Point; *for mail*, P. O. Box 123.
DAS, Peter ('26), M. E., Stand. Brands, Inc.
FIMIAN, Rudolph (J'31), Prop., Fimian Engrg., 1006 Park St.
FISHER, Chas. E., Jr. (J'27), Asst. M. M., Mech. Dept., Stand. Brands, Inc., Charles Point; *for mail*, 424 Dyckman St.
NYFFELER, Otto W. (J'31), Stand. Brands, Inc.
PATITZ, G. N. (J'36), Service Engr., Foster Wheeler Corp., Carteret, N. J.; *home address*, 1601 Maple Ave., Peekskill, N. Y.
WOOD, John T. (J'32), 213 Depew St.

PELHAM, Metropolitan Section

MILLER, J. Alfred ('30), 79 Harmon Ave.
MUESSEL, Chas. A. (J'36), 619 Esplanade.

PELHAM MANOR, Metropolitan Section

BARCLAY, H. W. (A'35), 8 Garden Pl.

PHILIPSE MANOR, Metropolitan Section

BRUMBLE, W. C. ('18; '25), 114 Farrington Ave.

PIERMONT, Metropolitan Section

ENGEL, Carl R. ('28), Mill Engr., Robt. Gair Co.

PLATTSBURG

HENSHAW, Chas. N. ('26; '35), 20 Wells St.

PLEASANTVILLE, Metropolitan Section

LENHARD, Robt. E. (J'34), Oper., Air Reduction Sales Corp., 42nd St., Lincoln Bldg., New York; *for mail*, 35 Wilton Rd., Pleasantville.

PORT CHESTER, Metropolitan Section

BURDSALL, Ellwood ('80; '16), Treas., Engr., Russell Burdsall & Ward Bolt & Nut Co., Midland Ave.
NELSON, Harry Ivan R. (J'34), Asst. Supt., Charge of Mfg., Life Savers, Inc., N. Main St.; *for mail*, 20 Halstead Ave.
WURTH, Fred (J'36), 16 Woodland Dr.

PORT IVORY, S. I., Metropolitan Section

PUISHES, A. (J'30), M. M., Procter & Gamble Co., Port Ivory; *for mail*, 381 Woodstock Ave., Tompkinsville, S. I.
SARTORIUS, Wm. J. ('28; '35), M. E., Charge Constr., Procter & Gamble Mfg. Co., Port Ivory; *for mail*, 614 Bard Ave., S. I.

PORT RICHMOND, S. I., Metropolitan Section

JONES, Wm. A. ('06), Cons. Engr., 202 Dickie Ave.
NELSON, Arthur J. (J'35), 132 Lexington Ave.
PARKER, Geo. Alfred ('13), 374 Heberton Ave.

PORT WASHINGTON, L. I., Metropolitan Section

BAUER, Geo. C. (J'36), 6 Shore View Rd.
FRANKLIN, Paul A. ('15; '25), Treas., Macpherson Bldrs., Inc., P. O. Box 332.
KIRKUP, Jos. P. ('08; '12), 11 Murray Ave.
MORRISON, Lacey H. ('18; '32), 3 Highland Ave.
PULLER, Otto G. ('19; '35), 32 Park Ave.
SWAIN, Philip W. ('16; '20; '25), Editor, Power, McGraw Hill Publ. Co., Inc., 330 W. 42nd St., New York, N. Y.; *for mail*, 8 Stratford Rd., Port Washington, L. I.

POTSDAM

BAILEY, Chas. S. (J'36), 81 Main St.
DAVIS, Jess H. (J'29), Asst. Prof. M. E., Clarkson College of Tech.; *for mail*, 11 Broad St.
ROSS, John A., Jr. ('16), Dean of Admin., Clarkson College of Tech.; *for mail*, 18 Lawrence Ave.

POUGHKEEPSIE, Metropolitan Section

BRILL, Geo. M. ('91; '96; F'36), Manager, '04-'07; Vice-President, '10-'12; Cons. Engr., 25 Beaver St., New York; *for mail*, 19 Kingston Ave., Poughkeepsie.
BURNS, Raymond W. ('19; '35), Secy., Treas., Jas. L. Taylor Mfg. Co., 108 Parker Ave.; *for mail*, 18 Barclay St.
CARLSON, Harry N. (J'26), 162 N. Clinton St.
DEXTER, Harris E. ('17; '35), Gen. Commercial Mgr., Cent. Hudson Gas & Elec. Corp., 50 Market St.
DURBECK, Albert C. ('21; '23; '35), Sales Engr., Fed. Bearings Co., Inc.; *for mail*, 73 Hinkley Pl.
FLOWERS, Alan E. ('16), Engr., Charge Devel., De Laval Separator Co.
HARGRAVE, Russell W. ('99; '14), Cons. Engr., 27 Manchester Rd.
HOE, Robt. ('13).
HORN, Robt. J. ('22; '26; '35), Gas Engr., Cent. Hudson Gas & Elec. Corp., 50 Market St.
HOWE, Albert W. ('03), R. F. D. 2.
JAMES, Robt. F. (J'22), Sales Engr., Interstate Plumbing Supply Co.; *for mail*, 401 E. Cedar St.
MILLER, Theo. H. ('06), Wks. Mgr., De Laval Separator Co.
QUARTERMAN, Edw. A. (J'31), Surveyor, Charge Party, Dutchess Co. Planning Comm., Dale Bldg.; *for mail*, 53 Maple St.
RECKNAGEL, F. W. (J'30), Designing, Exper. & Testing, Fed. Bearings Co., Inc.; *for mail*, 26 Fairview Ave.
RICHARDS, Keene ('27), Gen. Mgr., Cons. Engr., Vassar College.
SPROSS, Hubert M. ('27), Ch. Draftsman, De Laval Separator Co., Pine St.; *for mail*, 1 Fairmont St.
STREZYNSKI, Geo. J. ('35; '35), 59 College Ave.
WEISS, Paul A. H. ('18; '25; '35), M. E., Steam & Oil Eng. Power, Cent. Hudson Gas & Elec. Corp., South Rd.
WILLSON, Geo. T. ('20), Asst. Gen. Supt., De Laval Separator Co.; *for mail*, 2 May St.
WINCHESTER, Henry F. ('33; '35), Research Chemist, Am. Brake Shoe & Fdy. Co., Mahwah, N. J.; *for mail*, 14 Park Ave., Poughkeepsie, N. Y.

PRINCE BAY, S. I., Metropolitan Section

DAVIDSON, John C. ('15), Plant Engr., S. S. White Dental Mfg. Co.; *for mail*, 449 Prince Bay Rd.
GROOME, Warren (J'36), M. E., Research & Devel. Lab., S. S. White Dental Mfg. Co., Prince Bay; *for mail*, 561—61st St., Brooklyn.
LENG, Richard B. (J'35), M. E., Bur. Dept., S. S. White Dental Mfg. Co., Prince Bay; *for mail*, 17 Pearl St., Grymes Hills, S. I.
RYAN, S. Gilbert (J'31), Planning Dept., S. S. White Dental Mfg. Co., Prince Bay, S. I.; *for mail* 76 E. 79th St., New York.
TALBOT, Jas. M. ('13; '19), Factory Mgr., S. S. White Dental Mfg. Co.

QUEENS VILLAGE, L. I., Metropolitan Section

HESSE, Adolf ('27; '35), M. E. Ch. Engr., Kennedy, Van Saun Mfg. & Engrg. Corp., 2 Park Ave., New York; *for mail*, 110-40—213th St., Queens Village, L. I.
REPKO, John S. ('15; '22; '35), 94-22—212th St.
STAPPERT, Otto E. ('34; '35), M. M., Anchor Cap & Closure Corp., 22 Queens St., Long Island City; *for mail*, 9337—216th St., Queens Village, L. I.
WILSON, Lionel Jos. (J'35), Statistician, Fagan & Goetz, 40 Wall St., New York; *for mail*, 216-19—94th Rd., Queens Village, L. I.

REGO PARK, L. I., Metropolitan Section

YOERGER, Frank ('27; '35), 8866—62nd Dr.

RENSSELAER, Schenectady Section

CLARK, Jas. E. (J'27), Asst. Tax Valuation Engr., N. Y. State Dept. Taxation, Albany; *for mail*, 11 Aiken Ave., Rensselaer.

RICHLAND

CARR, Hugh H. ('31; '35), Gen. Factory Mgr., Wm. P. Curtiss & Son; *for mail*, P. O. Box 105.

RICHMOND HILL, L. I., Metropolitan Section

BENNETT, Harry G., Jr. (J'32), 109-24—111th St.
DIEKMANN, Henry A. (J'34), 9564—113th St.
HAGGERTY, R. T. (J'36), Jr. Engr., J. Chesler & Sons, Inc., 41 Varick Ave., Brooklyn; *for mail*, 104-16—120th St., Richmond Hill, L. I.
HOCHULI, John H. ('28; '35), Asst. Engr., Mech. Design, Phoenix Engrg. Corp., 2 Rector St., New York; *for mail*, 9723—120th St., Richmond Hill, L. I.
HOLZMACHER, Russell A. (J'36), 113-17 Jamaica Ave.
LIBBY, James M. (J'36), 9529—118th St.
MASTERS, Joseph (J'36), M. E., Charge Prod., Maint., Light Corrugated Box Co., 37-08 Northern Blvd., Long Island City; *for mail*, 115-09 Liberty Ave., Richmond Hill, L. I.
NOLDE, Arthur M. (J'33), 8611—106th St.
WILLIAMS, Robt. G. (J'34), 10764—116th St.
WINTERS, Fred H. ('35), 117-16—84th Ave.

ROCHESTER, Rochester Section

ALEXANDER, Chas. Anderson ('99; '05), 1260 Clover Rd.
ANCONA, John F. ('04; '12), Cons. Engr., Room 310, 311 Alexander St.
ANDERSON, Bror G. ('27; '35), Mch. Design, Engrg. & Maint., Kodak Pk. Wks., Eastman Kodak Co.; *for mail*, 133 Keehl St.
ARTHUR, Russell W. ('27; '34), Asst. Engr., Mch. Design, Kodak Pk. Wks., Eastman Kodak Co.; *for mail*, 119 Wellington Ave.
ATTERBURY, Thos. W. ('23), Designing Engr., Rochester Gas & Elec. Corp., 89 East Ave.; *for mail*, 21 Milton St.
BARROWS, Donald S. ('21), V. P., Symington-Gould Corp. & Gould Coupler Corp., 20 Symington Pl., Box 993.
BAUSCH, Carl L. ('11; '13; '21), V. P., Charge Engrg., Bausch & Lomb Optical Co., 635 St. Paul St.
BAXTER, Meriwether L., Jr. (J'35), Engr., Gear Theory & Research, Gleason Wks., 1000 University Ave.; *for mail*, 325 Alexander St.
BIRKICHT, E. Roy (J'34), Asst. M. E., Kodak Pk. Wks., Eastman Kodak Co.; *for mail*, 86 Raines Park.
BROWN, Wm. J. (J'35), Research Engr., Taylor Instrument Cos., 95 Ames St.
BRYANT, W. W. (J'35), M. E., Eastman Kodak Co., 333 State St.
BUSHLEY, H. Richard ('26; '33; '35), Dist. Sales Mgr., Elliott Co., 916 Temple Bldg.
CALA, Chas. F. (J'34), Foreman, Charge Glass Making, Bausch & Lomb Optical Co., 635 St. Paul St.; *for mail*, 144 Hoover Rd.
CAMP, Louis Foster, Jr. (J'36), In Training, Gleason Wks., 1000 University Ave.; *for mail*, 183 Harvard St.
CANDEE, Allan H. ('20; '28), M. E., Design & Research, Gleason Wks., 1000 University Ave.; *for mail*, 404 Hillside Ave.
CASTLE, Kendall B. (J'25), Engr., Indus. Dept., Rochester Gas & Elec. Corp., 89 East Ave.; *for mail*, 67 Council Rock Ave., Brighton Sta.
CATHER, Jay Howard ('19; '24), Asst. Supt., Charge Power, Kodak Pk. Wks., Eastman Kodak Co.; *for mail*, 285 San Gabriel Dr.
CONTA, Lewis D. (J'36), Instr., Univ. of Rochester, River Blvd.
COOPER, Richard F. (J'36), 100 Gibbs St.
COWELL, Warner T. ('25), M. E., Gleason Wks.; *for mail*, 70 Vermont St.
CROCKER, Allen S. ('05), Private Cons. Engr., 311 Alexander St.
DAVENPORT, Wm. S. ('13), Pres., Gen. Mgr., Davenport Mch. Tool Co., Inc., 167 Ames St.
DECKER, Harold A. (J'31), Asst. Engr., Power Devel., Kodak Pk. Wks., Eastman Kodak Co.
DEWOLF, Roger D. ('14), Pres., DeWolf Furnace Corp., Cons. Combustion Engr., N. Y. Cent. R. R., 119 E. Main St.
DONALDSON, Cyril ('27; '30; '35), Rochester Athenaeum & Mechanics Inst.
DUNGAN, E. Root ('30), M. E., 14 Franklin St., Rochester; *for mail*, 25 N. Main St., Albion.
EAST, Leo Herbert ('27; '35), Asst. Supt., Gas Dist. Dept., Rochester Gas & Elec. Corp., 89 East Ave.; *for mail*, 1392 Monroe Ave.
EDWARDS, Howard B. (J'36), 9 Granger Pl.
ENGELHART, Lawton C. (J'36), Test. Engr., Power Dept., Eastman Kodak Co.; *for mail*, 61 Parkdale Terrace.
EVANS, Fred'k H. ('18), Cons. Engr., 67 Furman Crescent.
FERGUSSON, David ('15), Ch. Engr., Jas. Cunningham Son & Co., 13 Canal St.
FIRESTONE, Siegmund ('12), Arch. & Engr., 59-61 South Ave.
FLINT, Chas. K. ('27), Gen. Mgr., Kodak Park Wks., Eastman Kodak Co.
FOWLER, Herbert E. ('31), Cons. Engr., 183 E. Main St.
FREEMAN, Herbert S. ('15; '22), Mfg. Agent, 49 Darwin St.
GAVETT, Jos. W. ('21; '24), Prof. M. E., Univ. of Rochester.
GLASSER, Howard C. (J'33), 326 Laurelton Rd.
GLEASON, Jas. E. ('22), Pres., Gleason Wks., 1000 University Ave.
GOELTZ, Philip H. (J'29), Design Engr., Gleason Wks., 1000 University Ave.; *for mail*, 236 Orange St.

HARDING, Howard ('14; '35), M. E., W. S. Barstow & Co., 89 East Ave.; *for mail*, 29 Kingston St.
HESS, Alfred I. (J'29), Indus. Engr., Kodak Park Wks., Eastman Kodak Co.; *for mail*, 139 Bakerdale Rd.
HOLTGREWE, Elwyn A. (J'30), Indus. Engr., Indus. Economy Dept., Eastman Kodak Co.; *for mail*, 235 Flower City Park.
HOOKER, Theo. F. ('24; '32; '35), Staff Engr. Bldg. 30, Kodak Park Wks., Eastman Kodak Co.
HOUSTLE, A. E., Jr. (J'34), 541 Lakes Ave.
HUBBARD, Karl H. ('36), Research Dir., Taylor Instrument Cos., 95 Ames St.
HUCKERT, Jesse W. ('29), Foreman, Charge RH-2 Dept., Bausch & Lomb Optical Co., 635 St. Paul St.; *for mail*, 312 Rawlinson Rd.
JENSEN, Einar W. (J'35), M. E., Exper. & Design, Research Lab., Kodak Pk. Wks., Eastman Kodak Co.; *for mail*, 249 Maplewood Dr.
JEWETT, Earold C. ('27; '35), Asst. Engr. Power. Eastman Kodak Co.; *for mail*, 54 Kemphurst Rd.
JOHNSON, Geo. M. (J'29), Asst. Supt., Sta. 8, Rochester Gas & Elec. Corp., 89 East Ave.; *for mail*, 70 Cedarwood Rd.
JOHNSTON, E. Wainwright ('24; '31; '35). Sales Engr., Abrahamson Corp., 45 Chestnut St.
JONES, Albert I. ('92), Factory Mgr., Pfaudler Co., 217 Cutler Bldg.; *for mail*, 369 Maplewood Ave.
JONES, John G. ('20), M. E., Supt. Mchy. Equip., Kodak Park Wks., Eastman Kodak Co.; *for mail*, 129 Trafalgar St.
KNOWLTON, Col. Frederic K. ('04; '17; '25), Pres., M. D. Knowlton Co., 28 Industrial St.
LEE, Maynard De Wilton ('30), Indus. Engr., Eastman Kodak Co.; *for mail*, 100 Chestnut Hill Dr.
LEE, Robt. T. (J'36), Training Course, Eastman Kodak Co., 343 State St.; *for mail*, 300 Meigs St.
LITTLEFIELD, Laurence T. (J'31), M. E., Kodak Park Wks., Eastman Kodak Co.; *for mail*, 851 Winona Blvd.
LOVEJOY, Frank W. ('01; '14), Pres., Eastman Kodak Co., 343 State St.; *for mail*, 56 Berkeley St.
LOWREY, Frank S. ('25; '33), Engr. & Estimator, Wm. Summerhays Sons Corp., 620 Clinton Ave., S.; *for mail*, 52 Avalon Dr.
MAHAN, Orlando E. ('31; '34; '35), Sales Engr., Schiefer Elec. Co., 89 East Ave.; *for mail*, 344 Lakeview Park.
MARQUIS, F. P. (J'35), Refrig. & Water Wks. Devel., Kodak Park Wks., Eastman Kodak Co.; *for mail*, 25 Hanford Landing Rd.
MARTH, Herbert (J'29), Asst., Prod. Dept., Taylor Instrument Cos., Ames St.; *for mail*, 435 Hayward Ave.
MASON, H. Lea ('25; '31; '35), Research Engr. Taylor Instrument Cos., 95 Ames St.
McCHESNEY, Irvin G. (J'24), Testing Engr. Rochester Gas & Elec. Corp., Rochester; *for mail*, 609 S. Washington St., E. Rochester.
McGUIRE, Erwin J. (J'29), State Safety Rep. Wks. Progress Admin., N. Y. State, Broadway, Albany; *for mail*, 418 Glen Ellyn Way. Rochester.
MORETON, John B. ('29), Sales Engr., Consltd. Mch. Tool Corp., 565 Blossom Rd.; *for mail*, 29 Farrington Pl.
NELSON, Geo. H. (J'26), Indus. Engr., Eastman Kodak Co., 1669 Lake Ave.; *for mail*, 32 Rand St.
NOYES, Henry T. (A'04), Gen. Mgr., Art in Buttons, Inc., Box 599.
O'BRIEN, Loren J. (J'36), Gear Engrg., Calculating, Gleason Wks., 1000 University Ave.; *for mail*, 17 Birch Crescent.
PAGE, Schuyler C. ('30; '35), Ch. Oper. Engr., Am. Laundry Mchy. Co.; *for mail*, 146 Devonshire Court.
PALMER, Virgil M. ('05; '14), Engr., Indus. Economy, Kodak Pk. Wks., Eastman Kodak Co., 1669 Lake Ave.
PERAGALLO, Jos. ('28; '33; '35), Design Draftsman, Kodak Park Wks., Eastman Kodak Co.; *for mail*, 141 S. Fitzhugh St.
PIGAGE, Leo C. (J'36), Time Study, Bausch & Lomb Optical Co.; *for mail*, 27 Ravenwood Ave.
POPE, Harold L. ('05; '12), 361 Sagamore Dr.
POWELL, Ivan E. ('22), Supt., Steam Generation & Distribution, Rochester Gas & Elec. Corp., 89 East Ave.; *for mail*, 138 Rugby Ave.
PRATT, Hazen C. ('22; '36), Engr., Charge Design, Otto Bernz, Inc., 280 Lyell Ave.
PUNNETT, Frazer D. (J'34), Asst. in Sales Dept., Gleason Wks., 1000 University Ave.; *for mail*, 1776 Ridge Rd., W.
RAMAGE, Raymond W. ('18; '26; '35), Safety Engr., Wks. Progress Admin., P. S. 12, S. Clinton & Marshall Sts.; *for mail*, 121 Castlebar Rd.
ROSCOE, Edwin S. ('27; '35), Research Engr., Yawman & Erbe Mfg. Co., 1099 Jay St.; *for mail*, 223 Vassar St.
ROSS, Cleland C. ('15; '22; '29), Mfrs. Rep., 82 St. Paul St.; *for mail*, 121 Penfield Rd.
SALISBURY, Frank R. (J'34), 110 Ridgeway Ave.
SCHELL, Albert E. ('22; '35), Design Engr., Spec. Mchy., Stromberg-Carlson Tel. Mfg. Co., 100 Carlson Rd.; *for mail*, 129 Stone Rd. Charlotte Sta.
SCHERER, Francis R. ('23), Arch. & Deputy Supt. of Sch. Bldgs., Bd. of Education, 13 S. Fitzhugh St.
SLAYTON, Ensign T. (J'30), Gear Engr., Gleason Wks., 1000 University Ave.; *for mail*, 215 W. High Terrace.
SNYDER, Jas. H. ('21; '34), Ch. Draftsman. Pfaudler Co., 89 East Ave.; *for mail*, 196 Roslyn St.
SONDERMAN, Herman C. ('17; '35), Asst. Engr. Eastman Kodak Co.; *for mail*, 263 Alameda St.
SPRAGUE, Oscar V. ('21; '35), Engr., Charge Power Oper., Kodak Pk. Wks., Eastman Kodak Co.
STACY, Stanley C. ('21; '25; '35), M. E., Bd. of Education, 13 S. Fitzhugh St.
STEINER, Oscar ('29; '35), Asst. Ch. Engr., Folmer Graflex Corp., Broad & Clarissa Sts.; *for mail*, 354 Titus Ave.
SUMMERHAYS, Louis J. ('25), V. P., Ch. Engr., Wm. Summerhays Sons Corp., 620 Clinton Ave. S.
SWIFT, Lewis B. ('29), V. P., Charge Research. Design & Engrg., Taylor Instrument Cos., 95 Ames St.; *for mail*, 37 Hancock St.
TEFFT, Henry Royal (J'36), Tool Engr., Gleason Wks., 1000 University St.; *for mail*, 183 Harvard St.
THOMPSON, Clifford F. (J'21), Design Engr. Delco Appliance Corp., 391 Lyell Ave.; *for mail*, 70 Lakeview Park.
TURK, J. C. (J'36), Engrg., Mech. Equip. Sec., Eastman Kodak Co.; *for mail*, 117 Keehl St.
ULMSCHNEIDER, Lawrence A. (J'29), Mch. Design, Eastman Kodak Co.; *for mail*, 367 Knickerbocker Ave.
VAN VECHTEN, Geo. C. ('22; '35), Partner. Stoker & Boiler Co., 217 East Ave.
WATKINS, Arold ('30; '35), Draftsman, Kodak Park Wks., Eastman Kodak Co.; *for mail*, 221 Goodwill St.
WELSH, Jack R. (J'36), Engr., Gas Htg. Div., Rochester Gas & Elec. Corp., 101 East Ave.; *for mail*, 2619 Highland Ave.
WESSON, Paul B. ('12), Engr., Kodak Pk. Wks., Eastman Kodak Co.; *for mail*, 121 Gorsline St.
WESSON, Rufus (J'36), Trainee, Eastman Kodak Co., 343 State St.
WILDHABER, Ernest ('23; '35), M. E., Research & Theory, Gleason Wks., 1000 University Ave.; *for mail*, 192 Wisner Rd.
WOLFE, Bernard J. ('25; '33; '35), Designing Engr., 310 Driving Park Ave.

ROCKAWAY BEACH, L. I., Metropolitan Section

NEEFUS, Jas. L. (J'33), 254 Beach 136th St.

ROCKVILLE CENTER, L. I., Metropolitan Section

ANDERSON, John W. ('13; '19), Cons. Engr., 135 Broadway.
CLURMAN, Will N. ('31; '35), Mgr., Petroleum Heat & Power Co., 154 Merrick Rd.
DICKINSON, W. N. ('35), 41 Woodland Ave.
DORAN, Chas. S. ('27), 169 Foxhurst Rd.
EDWARDS, Leroy V. ('19; '26; '35), 32 Irving Pl.
GENDALL, Gilbert H., Jr. (J'35), 333 N. Forest Ave.
LISTER, W. Harry (J'29), Pres., W. Harry Lister Automobiles, Inc., 133 Sunrise Highway.
McCROHAN, Edwin B., Jr. (J'27), Naval Arch., Navy Yard, Brooklyn; *for mail*, 81 Kennedy Ave., Rockville Center.

ROCKY POINT, L. I., Metropolitan Section

THORNE, E. Dayton ('23; '26; '35), Engr., Charge Drafting, RCA Communications, Inc., Rocky Point; *for mail*, 171 Jennings Ave., Patchogue, L. I.

ROME, Utica Section

FINKELSTEIN, Philip (J'32), M. E., Prod. Dept., Revere Copper & Brass, Inc.; *for mail*, 420 N. Washington St.
LAWTON, Henry H. (J'29), Clerk, Order Entry Dept., Rome Plant, Gen. Cable Corp.; *for mail*, 901 N. George St.
MUELLER, Paul M. ('23; '24; '35), Rome Mfg. Div., Revere Copper & Brass, Inc.; *for mail*, 800 N. George St.
PARRY, Edwin J. ('30; '35), Asst. Engr., Research & Devel., Rome Mfg. Div., Revere Copper & Brass, Inc., Rome, N. Y.; *for mail*, 3607—20th St., N. E., Washington, D. C.

ROOSEVELT, L. I., Metropolitan Section

SCHNEIDER, Philip Jos. (J'33), 42 Granada Ave.

ROSEDALE, L. I., Metropolitan Section

KROMER, Arthur P. (J'36), Engr., Charge Design, D. & W. Metal Products, 442 E. 166 St., New York; *for mail*, 240-01—143rd. Ave., Rosedale, L. I.

ROSLYN, L. I., Metropolitan Section

RAMSAUER, Edward C. (J'33), E. Broadway.
WILLIAMS, Arthur (A'15), Brook Corners.

ROSLYN HEIGHTS, L. I., Metropolitan Section

TERRELL, Wm. A. ('35; '35), Pres., Nordee Bldg. Co., Inc., 200 Mineola Ave., Roslyn Heights. L. I.; *for mail*, 160 Capitol Ave., Williston Park, N. Y.

RYE, Metropolitan Section

HAMTON, Maurice (J'30), Research Engr., New Departure Mfg. Co., Main St., Bristol, Conn.; *home address*, 36 Dearborn Ave., Rye, N. Y.; *for mail*, 106 Maple St., Bristol, Conn.
HOFFHINE, John ('30), Cons. Engr., Westchester Country Club.
MACNAMARA, M. J. ('21; '35), North St. & Highland Rd.

SAG HARBOR, L. I., Metropolitan Section

EATON, Wm. S. ('30), Engr., Ch. of Bd., Engravers & Printers Mchy. Co.
McMAHON, John, Jr. (J'35),

ST. ALBANS, L. I., Metropolitan Section

MANGELS, Herbert E. (J'33), 109-70—200th St.

ST. GEORGE, S. I., Metropolitan Section

BENNETT, Geo. L. ('05), 150 Daniel Low Terrace.
CARR, Arthur A. (J'36), Asst. to Maint. Engr., Quaker Maid Co., Inc., 45 Washington St., Brooklyn; *for mail*, 26 Montgomery Ave., St. George, S. I.
KRAUSE, Robt. M. ('30; '35), 201 Hamilton Ave.

SCARSDALE, Metropolitan Section

AMMANN, H. L. ('22; '31), Partner, Ammann & Reichen, 11 W. 42nd St., New York; *for mail*, 36 Bretton Rd., Scarsdale.
DEXTER, Gregory M. ('19), Engr., Charge Mgmt. Reports, Bitting, Inc., 20 Exchange Pl., New York; *for mail*, 32 Fenimore Rd., Scarsdale.
GANG, Oliver F. (J'20), Asst. Gen. Sales Mgr., Wm. Powell Co., Cincinnati, Ohio; *for mail*, 118 Brite Ave., Scarsdale, N. Y.
HENSHAW, Franklin ('34), Mgr., Engr., Water Dept., Village of Scarsdale, Village Hall.
KEPPLER, Paul Wm. (J'26), Testing Engr., N. Y. Edison Co., Inc., 134th St. & Locust Ave., New York; *for mail*, 82 Lee Rd., Scarsdale.
VAN SCHAICK, Geo. Donald (J'36), Aero. Instrument Calibrator, Sperry Gyroscope Co., Inc., Flatbush Ave. Ext., Brooklyn; *for mail*, 12 Carman Rd., Scarsdale.

SCHENECTADY, Schenectady Section

ABBATIELLO, Anthony A. (J'30), Maint. Engr., Gen. Elec. Co.; *for mail*, 526 Paige St.
ADAMS, John Quincy ('19; '26; '30), Engr. on Matl. Applications, Gen. Elec. Co.; *for mail*, 1351 Union St.
ALGER, Philip L. ('23; '35), Engrg. Staff Asst., Gen. Elec. Co.; *for mail*, 1758 Wendell Ave.
AMBROSE, Eugene R. (J'30), Air Conditioning Dept., Gen. Elec. Co., Schenectady; *for mail*, 227 Alexander Ave., Scotia.
ANDERSON, Jasper E. (J'30), Engr., Welding Engrg. Dept., Gen. Elec. Co., Schenectady; *for mail*, 501 Charles St., Scotia.
ANDERSON, Marshall (J'33), *Charles T. Main Award*, '32; Design Engr., Gen. Elec. Co.; *for mail*, 628 Nott St.
APPERSON, John S. ('21), Engr., Gen. Dept., Gen. Elec. Co.
ASHWORTH, George B. ('25), Engr., Charge Design, Am. Loco. Co.

AYRES, Russell W. ('20; '23; '35), M. E., Mgrs. Staff, Gen. Elec. Co.
BARTON, Richard B. (J'36), 1860 Albany St.
BEACHLER, Edw. D. (J'35), Indus. Control, Engrg. Dept., Gen. Elec. Co.; *for mail*, 2703 Campbell Ave.
BECK, Walter A. (J'26), 1140 Garner Ave.
BENNETT, Frank S. ('22), M. E., Constr. Engrg. Dept., Gen. Elec. Co.
BIGGER, Trafford W. ('26; '35), M. E., Design Boilers, Gen. Elec. Co.; *for mail*, 1317 Regal Ave.
BLUNT, Jas. G. ('19), Ch. M. E., Am. Loco. Co.
BLUNT, Richard Royal (J'34), Student Test Engr., Constr. Dept., Gen. Elec. Co.; *for mail*, 2020 Euclid Ave.
BRECHT, David C. (J'35), M. E., Engrg. Gen. Dept., Gen. Elec. Co.; *for mail*, 2703 Campbell Ave.
BROOKS, Wm. Travis (J'36), Student Engr., Testing, Gen. Elec. Co.; *for mail*, Y. M. C. A.
BUCKLAND, Bruce O. (J'24), Engr., Gen. Elec. Co., Bldg. 56; *for mail*, 1711 Randolph Rd.
BUNKE, Edw. W. D. (J'36), Student Engr., Testing Dept., Gen. Elec. Co., Schenectady; *for mail*, 1000 Woodycrest Ave., New York.
CAPP, John A. ('01), 1309 Union St.
CAUGHEY, Reed J. ('21), Engr., Charge Design. Gen. Elec. Co.; *for mail*, 1722 Eastern Pkwy.
CONNOR, Willard Harvey (J'36), Student Engr., Testing Dept., Gen. Elec. Co., Schenectady, N. Y.; *for mail*, 533 Home Ave., Ft. Wayne, Ind.
COXE, Nelson Y. (J'34), Student Engr., Testing Dept., Gen. Elec. Co.; *for mail*, 310 Colonial Apts., 9 N. Church St.
CRAWFORD, Thomas G. ('16), Staff Asst., Engrg. Gen. Dept., Gen. Elec. Co.
DADDARIO, Frank T. (J'36), Asst. Engr., Drafting & Design, Spence Engrg. Co., Inc., Grant St., Walden; *home address*, 720 Strong St., Schenectady.
DALTON, Wm. ('02), Gen. Engrg. Dept., Gen. Elec. Co.; *for mail*, R. D. 2.
DAVIS, E. F. (J'35), 1070 Willett St.
DAVIS, W. J., Jr. ('10), 9 N. Church St.
DAY, Jas. A. (J'35), Engr., Asst. to Supt., Steam Generating Stas., N. Y. Power & Light Corp., Amsterdam Steam Sta., Amsterdam; *for mail*, 902 Cleveland Ave., Schenectady.
DOUGLASS, Malcolm E. (J'36), Testing Engr., Cable Dept., Gen. Elec. Co.; *for mail*, 13 State St.
DWYER, Edward J. (J'33), Pat. Dept., Gen. Elec. Co., Schenectady, N. Y.; *for mail*, 1717 Troy St., Arlington, Va.
EGAN, Kyran Wm. ('28; '35), R. D. 1, Box 159.
ELLIOTT, Edw., Jr. (J'36), Student Engr., Gen. Elec. Co., Schenectady, N. Y.; *for mail*, 515 S. 7th St., Lafayette, Ind.
EMMET, Wm. LeR. ('02), *A. S. M. E. Medallist* '29; Cons. Engr., Gen. Elec. Co.
FLETCHER, J. Loren (J'32), Design Engr., Refrigeration, Gen. Elec. Co.
FOWLER, Francis R. (J'36), 1816 Union St.
FREER, Wm. G. ('14), Power Engr., Am. Loco. Co.
GARDINER, C. M. (J'32), Student Engr., Gen. Elec. Co.; *for mail*, 27 Catherine St.
GORE, Linn A. (J'34), Student Test Engr., Gen. Elec. Co.; *for mail*, 1307 State St.
HAUGHTON, Frank A. ('03), Cons. M. E., Gen. Elec. Co.; *for mail*, 1033 Avon Rd.
HEISLER, F. Wm. ('97; '09), M. E., Am. Loco. Co.; *for mail*, 108—14th St.
HOBART, Henry M. ('15), Cons. Engr., Gen. Elec. Co.
HOWARD, Thornton W. ('20; '35), Asst. Supt., Turbine Installations, Gen. Elec. Co.; *for mail*, 1394 Regent St.
HULL, Edwin H. (J'24), Research Lab., Gen. Elec. Co., Schenectady; *for mail*, 226 Ballston Ave., Scotia.
IGLEHART, R. Lannert (J'36), Test Man, Turbine Test Dept., Gen. Elec. Co.; *for mail* 628 Nott St.
JACKSON, Jas. A. ('22; '35), Application Engr., Matl. Handling, Indus. Engrg. Dept., Gen. Elec. Co.
JAMESON, Stanley L. (J'34), 730 Brandywine.
JOHNSON, Geo. L. ('29; '36), Turbine Engrg. Dept., Gen. Elec. Co.; *for mail*, 1408 Glenwood Blvd.
KAUFFMAN, Harold L. ('26; '35), P. O. Box 565.
KIMBALL, Arthur L. (A'24), Engr., Gen. Elec. Co.; *for mail*, 1546 Wendell Ave.
KNAPP, Edwin C. ('93; '32), Professional Engr., 1124 Parkwood Blvd.
KNOWLTON, P. Holland, Jr. (J'30), Asst. Engr., Turbine Dept., Gen. Elec. Co.
LANGMUIR, Irving (Non-Member), *Holley Medallist*, '34; Research Dept., Gen. Elec. Co.
LARRECQ, Anthony J. (J'29), Engr., Turbine Dept., Gen. Elec. Co.; *for mail*, 1760 Eastern Pkwy.
LIPETZ, A. I. ('19), Ch. Cons. Engr., Charge Research, Am. Loco. Co., Schenectady, N. Y.; also Non-Resident Prof. Loco. Engrg., Purdue Univ., Lafayette, Ind.; *for mail*, Am. Loco. Co., Schenectady, N. Y.
MARCHANT, Richard D. (J'36), Student Engr., Test Course, Gen. Elec. Co., Schenectady; *for mail*, 220 S. Edwards Ave., Syracuse.
MARSHALL, Thos. Hartley, Jr. (J'36), Engr., Gen. Elec. Co.; *for mail*, 642 Nott St.
McKENNEY, Jas. F. (J'36), Student Engr., Testing Dept., Gen. Elec. Co., Schenectady; *for mail*, 14 George St., Amsterdam.
MEYERHANS, Robt. Hall (J'36), 10 Hawk St.
MILLER, W. Prescott (J'36), Spec. Apprentice, Am. Loco. Co.; *for mail*, 1 Elmer Ave.
MUIR, R. C. ('22), V. P., Charge Engrg., Gen. Elec. Co.
NEAL, Stanford (J'36), 2703 Campbell Ave.
NERAD, Anthony J. ('30; '35), Research Engr., Gen. Elec. Co.; *for mail*, 418 Robinson St.
NEWKIRK, Burt L. ('26), Professional Engr., 17 Rosa Rd.
NISBET, Robt. A. (J'27), Student Engr., Gen. Elec. Co.; *for mail*, 39 Robinson St.
NORRIS, Rollin Hosmer (J'35), Gen. Elec. Co., Schenectady; *for mail*, 530 Charles St., Scotia.
OTTO, Harold McCall (J'32), M. E., Gen. Elec. Co.; *for mail*, 750 De Camp Ave.
PARKER, Edwin E. (J'35), Cons. Engr., Engrg. Gen. Dept., Gen. Elec. Co.
PETURA, Frank E. (J'36), Test Engr., Gen. Elec. Co., Schenectady, N. Y.; *for mail*, 535 Highland Ave., Westfield, N. J.
PLETTA, Wm. H. (J'36), Student Engr., M. E. Gen. Elec. Co.; *for mail*, 802 Eastern Ave.
PRAGST, Ernest ('28), Engrg. Wk., Cent. Sta. Dept., Gen. Elec. Co.
REED, Wm. Albert (J'28), Asst. to Supt., Refrig. Dept., Gen. Elec. Co.; *for mail*, 106 Woodland Ave.
REIST, Henry G. ('89; '93; F'36), Manager, '09-'12; Vice-President, '13-'15; Retired, Gen. Elec. Co.; *for mail*, 1166 Avon Rd.
ROBERTS, Jas. L. ('25), Asst. Installation Wk., Gen. Elec. Co.; *for mail*, 121 Balltown Rd.
ROBINSON, Ernest Leffert ('23), Turbine Engrg. Dept., Gen. Elec. Co.
RUIZ, Albert L. (J'30), Engr., Aero. & Mar. Dept. Gen. Elec. Co.
RYAN, John E. (J'34), 842 Union St.
SALISBURY, J. Kenneth (J'30), Turbine Engrg. Dept., Gen. Elec. Co.; *for mail*, 7 Wyoming Ave.
SAYRE, Mortimer F. ('22), Assoc. Prof. Applied Mechanics, Union College.
SCHMID, Ben J. (J'33), Test Engr., Gen. Elec. Co.; *for mail*, 1050 Glenwood Blvd.
SCUDDER, Hewlett ('99; '26), Asst. Pat. Atty., Gen. Elec. Co.
SHELDON, Lucian A. ('13), Engr., Mercury Vapor Sec., Turbine Engineering Dept., Gen. Elec. Co.
SHIRRELL, Chas. P. ('25), Mch. Design, Gen. Elec. Co., Bldg. 2, Rm. 131; *for mail*, 1649 Oneida St.
SHREVE, Earl O. ('16), V. P., Gen. Elec. Co.
SMITH, Arthur R. ('22), Engr., Constr. Engrg. Dept., Managing Engr. Turbine Dept., Gen. Elec. Co.; *for mail*, 832 Union St.
STEELE, Ralph Wayne (J'36), Student Engr., Gen. Elec. Co.; *for mail*, 922 State St.
STEVENSON, Alex. R., Jr. ('27), Gen. Elec. Co.
STONE, Chas. W. ('07), Cons. Engr., Gen. Elec. Co.
STREID, Dale D. (J'36), Student Engr., Gen. Elec. Co.
TANG, Bernhard G. ('29), Gen. Supt., Gen. Elec. Co.
TAYLOR, Richard M. (J'34), Student Engr., Gen. Elec. Co.; *for mail*, 802 Eastern Ave.
THEARLE, Ernest L. ('26; '35), Research Engr., Charge Mech. Sec., Gen. Elec. Co.; *for mail*, 1181 Sumner Ave.
THOMPSON, Edw. S. (J'31), Turbine Engrg. Dept., Gen. Elec. Co.; *for mail*, 1291 Belmont Ave.
WARREN, Glenn B. ('24; '30), Design Engr., Turbine Dept., Gen. Elec. Co.; *for mail*, 1361 Myron St.
WAY, Alva O., Jr. (J'30), Planning Engr., Gen. Elec. Co.; *for mail*, R. F. D. 7, Box 298.
WEBER, August, Jr. ('16), Pres., Weber Elec. Co., P. O. Box 1050.
WHITE, Robt. H. ('18), Engr., Charge Plant Design & Constr., Am. Loco. Co., N. Jay St.; *for mail*, 1444 Rugby Rd.
WOOD, Orla L., Jr. (J'24), Turbine Engr., Gen. Elec. Co.; *for mail*, 1472 Baker Ave.

SENECA FALLS, Syracuse Section

COZAD, M. Dudley (J'34).
GARNSEY, Hamilton, Jr. ('29; '35), Works Mgr., Goulds Pumps, Inc.
GOULD, Norman J. ('00; '08), Pres., Goulds Pumps, Inc.
MANN, John ('30), Ch. Engr., Charge Prod. Design, Goulds Pumps, Inc., 240 Fall St.
SMITH, Edwin R. ('21; '35), V. P. & Gen. Mgr., Seneca Falls Mch. Co., 314-340 Fall St.

SIDNEY

MORRELL, Milton C. (J'34), 95 River St.

SMITHTOWN, L. I., Metropolitan Section

BROWN, Jas. A. ('20).

SOLVAY, Syracuse Section

CRAIG, Howard B. (J'99), 161 Orchard Rd.
HILDRETH, K. E. ('17; '35), 4 Wilshire Rd.
LARSEN, A. M. ('29; '35), Asst. Design Engr., Solvay Process Co., Solvay; *for mail*, 300 Parsons Dr., Syracuse.
SHETLAND, Donald V. (J'34), Asst. Opera., Niagara Lockport & Ontario Power Co., Solvay; *for mail*, 147 W. Calthrop Ave., Syracuse.

SOUTHAMPTON, L. I., Metropolitan Section

LIND, Robert M. (J'32), Toylsome Lane.
SILVER, Max ('23; '35).

SOUTH OZONE PARK, Metropolitan Section

MARTIN, Harold C. (J'36), 120-35—147th St.

SPRINGFIELD, L. I., Metropolitan Section

BOND, Harry H., Jr. ('26; '31; '35), 141-49—181st St.

SPRINGFIELD GARDENS, L. I., Metropolitan Section

HUSSEY, Thos. O. ('23; '35), 133-49 Dennis Ave.

SPRING VALLEY, Metropolitan Section

THORNTON, Arthur F. ('21), Hickory St.

SPRINGVILLE, Buffalo Section

FELTON, George W. ('21), Ch. Engr., Charge Engrg. & Sales, Winfield H. Smith, Inc., 10 Eaton St., Springville, Erie Co.; *for mail*, 85 Milford St., Hamilton.

STAMFORD

CHURCHILL, Glenn E. (J'35).

STAPLETON, S. I., Metropolitan Section

ERRINGTON, Franklin A. ('06), Proprietor, Errington Mach. Lab., 24 Norwood Ave.; *for mail*, 6 Errington Pl.

STATEN ISLAND, Metropolitan Section

ATLAS, Reynold A. (J'36), 3016 Richmond Terrace.
AUG, Wm. F. (J'34), 446 Bement Ave.
BESTER, Leonard R. ('23), Designing Engr., United Shipbldg., Mariners Harbor; *for mail*, 90 St. Marks Pl., Staten Island.
CARELL, Walter S. (J'31), Oper. Engr., Procter & Gamble Co., Port Ivory; *for mail*, 50 Tompkins Circle, Staten Island.
CARLSON, Ernest G. (J'30), Time Study Engr., S. S. White Dental Mfg. Co., Prince Bay; *for mail*, 143 Harrison Ave., Staten Island.
CURREN, Ralph L. (J'36), 2688 Amboy Rd.
GERKEN, Henry A. (J'26), Ch. Engr., Charge Design, Edw. Ogden Co., E. 46th St., Bayonne, N. J.; *for mail*, 247 Potter Ave., Staten Island, N. Y.
HUMPHREY, Geo. S. ('01), Retired; 19 Hyatt St.
LANGLOTZ, Robt. ('94; A'04), Retired; C3 Unit 4, St. George Gardens.
LOGAN, Alex. (J'36), M. E., Inspr., Sperry Gyroscope Co., Flatbush Ave. Ext., Brooklyn; *for mail*, 258 Decker Ave., Staten Island.
MOLOKIE, Stephen W. ('17; '25; '35), M. E., Charge Constr., Research Corp., Bound Brook, N. J.; *for mail*, 188 Major Ave., Staten Island, N. Y.
WALLOE, Reidar ('27; '35), Designer, Tide Water Oil Co., 22nd St., Bayonne, N. J.; *for mail*, 246 DuBois Ave., Staten Island, N. Y.

SUFFERN, Metropolitan Section

HOPPER, Thos. W. (J'33), Prod. Supt., Allied Products Co., Inc.; *for mail*, 10 Oak Terrace.
WIEGAND, Monroe C. (J'34), 30 Jersey Ave.

SYRACUSE, Syracuse Section

ACHESON, Albert R. ('13), Cons. Engr., 501 Eckel Theatre Bldg.
ALDRICH, Wm. S. ('92), Life Member; 137 Buckingham Ave.
AMES, Millard R. (J'33), Indus. Engr., Crouse-Hinds Co., Wolf & 7th North Sts.

AVERY, Harold Terry ('14; '35), Ch. Engr., Potter & Dugan, Inc., 203 Herald Bldg.; *for mail,* 405 Westcott St.
BROWN, C. Travis (J'29), Engr., Charge Methods & Time Study, L. C. Smith & Corona Typewriters, Inc., 701 E. Washington St.; *for mail,* 808 Ackerman Ave.
BUMP, Burton N. ('92; '04), Life Member; Cons. Engr., 1210 Euclid Ave.
BURMESTER, R. Lawrence (J'34), Serv. Engr., Gates Rubber Co., 999 S. Broadway, Denver, Colo.; *for mail,* 1530 E. Genesee St., Syracuse, N. Y.
CLUNE, Jos. P. ('18), Asst. to V. P., Solvay Process Co.; *for mail,* 171 Robineau Rd.
DABANOFF, Raffi (J'36), Catalog, Easy Washing Mch. Corp., 128 Spencer St.; *for mail,* 129 Craddock St.
DIEFENDORF, D. W. (J'30), V. P., Diefendorf Gear Corp., 920 W. Belden Ave.; *for mail,* R. D. 3, MacDonald Rd.
FAILMEZGER, Eugene (J'33), Air Appliance Div., U. S. Hoffman Mch. Corp., Syracuse; *for mail,* 109 Wellington Rd., De Witt.
GORDON, R. M. ('02; '08; '12), Cons. Engr., 126 Dorset Rd.
GREEN, Ben H. ('21; '35), Supt. Maint. & Oper., Cent. Div., Niagara-Hudson Power Corp., 300 Erie Blvd.; *for mail,* 240 Homecroft Rd.
HART, Simeon T. ('24), Prof. Indus. Engrg., Syracuse Univ.; *for mail,* 168 Westminster Ave.
HILDRETH, W. O. ('88; '30), Engr., Lamson Co., Inc.; *for mail,* 321 Bruce St.
HOPTON, W. E. ('91; '96), Prin. Partner, Hopton Co., 321 Denison Bldg.
JAEGER, Ulric R. (J'34), 1017 Harrison St.
JEFFERSON, E. R. (A'26), 332 S. Warren St.
LOGUE, Chas. H. ('22), Cons. Engr., 123 Clarke St.
LONG, Robt. C. (J'27), Engr., Lamson Co., Inc.; *for mail,* 1145 Teall Ave.
LONGFIELD, Reynolds ('31), Methods Engr., Crouse-Hinds Co.; *for mail,* 121 Edgehill Rd.
LONGWELL, Henry E. ('01), 708 James St.
MONTAGUE, Chas. E. ('13; '18; '35), Pres., Engelberg Huller Co., 831 W. Fayette St.
MOYER, Malcolm B. ('28), Cons. Engr., 214 Ruhamah Ave.
MURRAY, W. H. G. ('20; '35), Pres., Smith-Murray Corp., 821 Burnet Ave.
PARKER, Henry M. (J'29), Engr., Charge Layout, Trump Corp., 440 E. Genesee St., Syracuse; *for mail,* R. F. D. 3, Skaneateles.
RHODES, Keith (J'29), M. E., Niagara-Hudson Power Corp., 300 Erie Blvd. W.; *for mail,* Schopfer Court.
RICHARDSON, Harold C. (J'25), M. M., Hygrade Sylvania Corp., Emporium, Pa.; *for mail,* 2533 W. Genesee St., Syracuse, N. Y.
ROBINSON, Almon L. ('19; '35), 109 Southview Rd.
RUSHEY, Donald Duane (J'32), Water Wks. Engr., City of Syracuse, 101 N. Beech St.; *for mail,* 232 W. Matson Ave.
SCHAFFNER, John W. ('31), Spec. Sales Rep., Lamson Co., Inc.; *for mail,* 708 Comstock Ave.
SHERMAN, Chas. N. (J'34), 224 Marguerite Ave.
SMITH, Elwyn L. ('19; '25; '34), Mem. Firm, L. C. Smith & Corona Typewriters, Inc., 701 E. Washington St.
SWEET, Robt. A. (J'35), 320 W. Calthrop Ave.
TRACY, Lyndon S. ('00; '15), Prod. Mgr., Solvay Process Co.
TRUMP, Edw. N. ('80; '90; F'36), Vice-President, '05-'07; Treas. & Cons. Engr., Sanitary Metal Cap Corp., 204 Hills Bldg., also V. P., Trump Corp.; *for mail,* 1912 W. Genesee St.
VINCENT, Gilbert I. ('13), Exec. Staff, Niagara-Hudson Power Corp., 300 Erie Blvd., W.
WILLIAMS, Morris F. (J'32), Asst. M. E. Maint. & Roll Designer, Sanderson Wks., Crucible Steel Co. of Am., 104 Magnolia St.; *for mail,* 116 Westview Ave.
WITHERBEE, Rex G. ('19), Engr., John L. Graham, Cons. Engr., 859 Onondaga Hotel, Syracuse; *for mail,* 6 Hawthorn Rd., New Hartford.
WOOD, Alonzo B. (J'36), Time Study, Easy Washing Mch. Corp., Spencer St., Syracuse; *for mail,* Main St., Elbridge, N. Y.
ZIMMERMAN, Earl W. ('26), Mgr., Trump Corp., 440 E. Genesee St.; *for mail,* 704 Bellevue Ave.
ZOHE, L. A. ('03; '04), 223 E. Kenney St.

TARRYTOWN, Metropolitan Section

GORDON, David (J'27), 76 N. Broadway.
SOMMER, Philip L. Jr. (J'33), Paint Dept., Chevrolet Motor Co., Tarrytown, N. Y.; *for mail,* 96 High St., Passaic, N. J.

TOMPKINSVILLE, S. I., Metropolitan Section

LARKIN, Wm. H., 3d (J'28), 48 Tompkins Circle.

TONAWANDA, Buffalo Section

BRITT, William H. (J'36), Asst. to Ch. Engr., Buffalo Pumps, Inc., 874 Oliver St., N. Tonawanda; *for mail,* 41 Grove St., Tonawanda.
COX, S. J. ('29), Plant Steam & Power Engr., Semet Solvay Co., Tonawanda; *for mail,* 64 Shepard Ave., Kenmore.
STAHL, Frank E. ('30), c/o Columbus McKinnon Chain Corp.
WOLTERS, Carl F. ('22; '35), Ch. Engr., Design & Prod., Remington Rand, Inc., Main St.

TOTTENVILLE, S. I., Metropolitan Section

LEUPOLD, Herbert W. (J'33), Time Study Engr., S. S. White Dental Mfg. Co., Prince Bay; *for mail,* 147 Sprague Ave., Tottenville, S. I.

TROY, Schenectady Section

AMSTUZ, John O. ('31), Ch. Engr., Behr-Manning Corp.
BARNUM, Theo. P. (A'15), Secy., Barnum Bros. Co., 179 River St.
BRYSON, Tandy A. ('16; '21), Cons. Engr., Route 3.
CLUETT, Albert E. ('00; '03), Exec. V. P., Troy Savings Bank, 2nd St.; *for mail,* P. O. Box 666.
CLUETT, Sanford L. ('03; '11), V. P., Charge Research, Cluett, Peabody & Co., Inc.
COOK, Marsden A. (J'30), Instr., Dept. M. E., Rensselaer Poly. Inst.
CORWIN, Elbert F. (J'30), Dept. of M. E., Rensselaer Poly. Inst.
CROCKETT, Chas. H. ('18; '21; '35), Engr., 221 Stow Ave.
DAY, Chas. I. ('10; '25), V. P., Gen. Mgr., W. & L. E. Gurley, 514 Fulton St.
DIBERT, Herbert M. ('18), Secy., Treas., W. & L. E. Gurley, 514 Fulton St.
FAIRFIELD, John G. ('17; '25; '35), Prof. Heat Engrg., Rensselaer Poly. Inst., 8th St.
FAYLES, R. Russell (J'36), 62 State St.
FESSENDEN, Edwin A. ('08; '14), Prof. M. E., Head of Dept., Rensselaer Poly. Inst.; *for mail,* 140 Oakwood Ave.
FITZGERALD, T. F. (J'29), Asst. Prof. M. E., Rensselaer Poly. Inst., 8th St.
FLYNN, Wm. S. (J'34), Engr., Sales Rep., Eddy Valve Co., Waterford; *for mail,* 83—3rd St., Troy.
FORSTER, John A. (J'36), Serv. Man, I. P. R. Div., Internatl. Business Mchs. Corp., 270 Broadway, New York; *for mail,* R. F. D. 3, Troy.
FOSTER, C. H. ('86), Life Member; Retired; Hotel Troy.
HAMMETT, Hiram G. ('88), Prop., Hammett Mch. Wks., 466-482—8th St., 27—2nd St.
HILL, Fred C. ('21; '35), Gas Engr., Hudson Valley Fuel Corp., 19—2nd St.
HOUSTON, Livingston W. ('19; '35), Pres., Ludlow Valve Mfg. Co.
KIDDER, Wilbur E. (J'34), Spec. Apprentice, W. Albany Shop, N. Y. Cent. R. R., Albany; *for mail,* 2204—14th St., Troy.
MALONEY, Michael J. ('21; '35), Supt., Rail Joint Co.
MANVILLE, Wm. W. (J'36), R. S. E. Sage Ave.
MUSSO, Alfred ('18; '24), Pres., Burden Iron Co.
PALSGROVE, Grant K. ('13; '21), Prof. Hyd. Engrg., Rensselaer Poly. Inst.; *for mail,* 1514 Sage Ave.
SALISBURY, Harold G. (J'32), Design, Devel. & Research Engr., 238—5th Ave.
SOLOMON, Gabriel R. ('16), Partner, Solomon & Keis, Cons. Engrs., 257 Broadway.
STEVENS, Howard E. ('24; '29), *Student Award,* '16; Prof. Mch. Design, Rensselaer Poly. Inst., 8th St.; *for mail,* 9 Rankin Ave.
TOMS, William E. (J'36), 1102 Peoples Ave.
VAN DENBURGH, O. A., Jr. ('16; '22; '25), V. P. & Gen. Mgr., Burden Iron Co.
VANDERVORT, Adrian O. ('00; '18), Supt., Hammett Mch. Wks.; *for mail,* 146 Oakwood Ave.
WARD, Lawrence C. (J'34), 10—1st St.
WHITE, Kenneth H. (J'30), Instr. M. E., Rensselaer Poly. Inst.
ZAPF, Norman F. (J'34), 1577 Tibbits Ave.

TUCKAHOE, Metropolitan Section

TURNBULL, Wm. F. ('23), 7 Cottage Ave.

UNADILLA

ESTY, F. Burrows (J'35), Box 433.

UTICA, Utica Section

CLEMENT, Walter J. ('19; '32), Ch. Engr., Pulverizing Mchy. Div., Bossert Corp.
MUNSON, Edmund G. ('08), 7 Springate St.
ORTON, Albert W. ('30), Factory Mgr., Partlow Corp., 2 Campion Rd., New Hartford; *for mail,* 39 Parkside Court, Utica.
VOLKHARDT, Walter (J'19), Hotel Martin.
WRIGHT, Howard E. (J'23), Plant Engr., Hart & Crouse Co., Turner St.; *for mail,* 1223 Taylor Ave.

VALLEY STREAM, L. I., Metropolitan Section

KAHRS, Henry G. (J'28), Asst. Mgr. Sales, Gas Consumers Assoc., New York; *for mail,* 227 N. Corona Ave., Valley Stream.
PICK, Wm. J. (J'35), 224 E. New York Ave.

WAPPINGERS FALLS, Metropolitan Section

BURKE, Henry M. ('20), Gen. Mgr., Dutchess Bleachery, Inc.; *for mail,* 16 Henry St.
FAXON, Francis E. ('19).
GOLRICK, Mark A., Jr. ('23; '31), Plant Engr. & Prod. Mgr., Dutchess Bleachery, Inc., Wappingers Falls; *for mail,* 6 Kingston Ave., Poughkeepsie.

WARRENSBURG

LANE, Augustus H. ('17; '21), P. O. Box 73.

WARSAW

PETTENGILL, Geo. D. ('23), Ch. Engr., Warsaw Elev. Co.; *for mail,* 14 Grove St.

WARWICK

SCHWENN, Eric (J'30), M. E., Charge Power Plant, N. Y. State Training Sch. for Boys.

WASHINGTONVILLE

MORRISS, Arthur D. ('19; '35), Box 251.

WATERFORD, Schenectady Section

KNICKERBACKER, John ('91), Pres., Eddy Valve Co., Waterford; *for mail,* 86—1st St., Troy.
WEAVER, Chas. J. ('28), Cons. Engr., 55 Broad St.

WATERTOWN

BOYER, Edwin D. ('21), M. E. Dept., N. Y. Air Brake Co., 120 Lexington Ave., New York; *for mail,* 301 Washington St., Watertown.
CAMPBELL, Chas. A. ('36), 123 S. Pearl Ave.
CARTIN, James D. ('19), Gen. Mgr., N. Y. Air Brake Co., Starbuck Ave.
CHAMBERLAIN, Gordon Lyle (J'31), Mech. Draftsman, N. Y. Air Brake Co., Starbuck Ave.; *for mail,* 130 Michigan Ave.
COURTENAY, Chas. R. ('14), Owner, Watertown Eng. & Mch. Co.
FIELD, Wm. T. ('31), Pres., Wm. T. Field Engrs., Inc., 40 Flower Bldg.
HALLADAY, Harry F. ('03; '13), M. E., N. Y. Air Brake Co., Starbuck Ave.; *for mail,* 1012 Washington St.
KINNE, Clarence E. ('99), Life Member; V. P., Charge Engrg., Bagney & Sewall Co., 101 Pearl St.; *for mail,* 116 S. Indiana Ave.
LAIRD, Alton Wilson ('31; '35), M. E., N. Y. Air Brake Co.; *for mail,* 410 Broadway Ave. E.
LENNO, Emery J. ('31), Engr., D. D. Kieff, R. A. Chamber of Commerce Bldg.; *for mail,* 178 Ward St.
SILLCOX, Lewis K. ('16; '18), 1st V. P., N. Y. Air Brake Co., Starbuck Ave.
SUDDUTH, H. N. (J'30), Asst. Engr., N. Y. Air Brake Co.
VALENTINE, Chas. W. ('27), Pres. & Gen. Mgr., Bagley & Sewall Co., 101 Pearl St.
VROMAN, Erwin C. ('29), M. E., N. Y. Air Brake Co.; *for mail,* 208 S. Indiana Ave.

WATERVLIET, Schenectady Section

SCHUBERT, Arno G. (J'31), Instr. M. E., Rensselaer Poly. Inst., Troy; *for mail,* 1301 Broadway, Watervliet.

WATKINS GLEN, Ithaca Section

TOBEY, W. Arthur ('26; '35), Plant Supt. & Engr., Watkins Salt Co.; *for mail,* 108—8th St.
WALSH, Carl Z. (J'34), Glen Springs.

WEBSTER, Rochester Section

MASON, Hugh A. (J'35), Condenser Engr., Ingersoll-Rand Co., 11 Broadway, New York; *home address,* 39 Dunning Ave., Webster.

WELLSVILLE

BROOKS, Alfred A. ('16; '26), Turbine Designer, Moore Steam Turbine Corp.; *for mail,* 309 W. State St.
CHURCH, Maynard D. ('12), Pres., Moore Steam Turbine Corp.; *for mail,* 392 N. Main St.
KARLSSON, Hilmer ('27; '35), Asst. Ch. Engr., Air Preheater Corp.; *for mail,* 102 Early St.
MACDONALD, Karl ('15; '23), Ch. Engr., Moore Steam Turbine Corp.; *for mail,* 355 W. State St.
SCHALLER, Alwin ('11; '21), Gen. Mgr., McEwen Bros.
SHIRES, Frank (J'31), Engr., Charge Testing, Power, Moore Steam Turbine Corp.; *for mail,* 47 N. Brooklyn Ave.
WAITKUS, Jos. (J'31), Engr., Superheater Co., Air Preheater Corp., 121 Main St.

WEST NEW BRIGHTON, S. I., Metropolitan Section

BALLER, Philip W. G. ('23; '25; '35), 193 Morrison Ave.
BLAKE, Alfred D. ('14; '22), Editor, Combustion, Combustion Engrg. Co., Inc., 200 Madison Ave., New York; *for mail*, 43 Colonial Court, W. New Brighton.
CAMPBELL, Norman J. (J'35), 144 Egbert Ave.
GIBSON, Harold D. (J'24), 86 Crosshill St.
HANNAN, Raphael Q. ('22; '24; '35), Inspr., Iron & Steel, Richmond County, City of N. Y.; *for mail*, 122 Mountainview Ave., W. New Brighton.
LOTZ, Ralph W. ('19; '23; '35), Prod. Mgr., Ford Instrument Co., Rawson St., Long Island City; *for mail*, 34 Clove Lake Pl., W. New Brighton.
MORSE, Edw. P. ('18), Pres., Gen. Mgr., Natl. Drydock & Repair Co., Inc., West Brighton.

WHITE PLAINS, Metropolitan Section

CLARKE, M. H. (J'35), Dist. Retail Mgr., Socony-Vacuum Oil Co., Inc., Edison Ave., Mt. Vernon; *for mail*, Broad Park Lodge, White Plains.
KAESTNER, Paul T. (J'35), Pur. Agt., Aqua Systems, Inc., 2443—3rd Ave., New York; *for mail*, 161 Longview Ave., White Plains.
LUTHER, Ward L., Jr. (J'35), 77 Bryant Ave.
SUPPICICH, Stephen J. (J'29), Jr. Engr., Westchester Asbestos Co., 58 Orawaupum St., White Plains; *for mail*, 3457 Eastchester Rd., New York.

WHITESTONE, L. I., Metropolitan Section

KROPP, Rupert Folger (J'34), Asst. Engr., Bldg. Inspector, Navy Yard, Brooklyn; *for mail*, 149-34—10th Ave., Whitestone.

WILLIAMSVILLE, Buffalo Section

SPIESZ, Carlysle P. (J'35), 22 Columbia Dr.

WOODHAVEN, L. I., Metropolitan Section

AUTH, Geo. H. (J'35), Inspr., Pioneer Instrument Co., 754 Lexington Ave., Brooklyn; *for mail*, 8907—91st St., Woodhaven.

WOODMERE, L. I., Metropolitan Section

BERGH, Roland C. (J'29), 128 Ocean Ave.

WOODSIDE, L. I., Metropolitan Section

BLAKE, Winchester G. ('26; '34), 5908—41st Ave.
BUCCOLA, Chas. H. (J'30), Devel. & Res. Engr., Philips Metalix Corp., 896 S. Columbus Ave., Mt. Vernon; *for mail*, 4155—70th St., Woodside.
CADWALLADER, Starr (J'33), 47-06—46th St.
MELICHAR, Jos. T. (J'33), Asst. Engr., Arbuckle Bros., Foot of Jay St., Brooklyn; *for mail*, 41-37—67th St., Woodside.
MYERS, Frank M. ('29; '35), M. E., Charge Cons. & Design, Mason Mfg. Co., 71 Fulton St., New York; *for mail*, 3940—51st St., Woodside.
STEEN, Herbert (J'33), 39-29—58th St.

YONKERS, Metropolitan Section

ARNOLD, Phillip J. ('23; '25; '35), Prod. Engr., Otis Elev. Co., 44 Wells Ave.; *for mail*, 551 Van Cortland Pk. Ave.
ASHCROFT, Alfred Griffin ('33; '34), Product Engr., Charge Product Research & Control, Alex. Smith & Sons Carpet Co.
BECKWITH, Oliver P. (J'36), Research Engr., Alex. Smith & Sons Carpet Co., 249 Park Ave.
BECKWITH, Wm. H. ('30; '35), Secy., Everard Tap & Die Corp., 213 E. 144th St., New York; *for mail*, 100 Wickes Ave., Yonkers.
BLAIR, Jas. G. (J'36), Drafting Engr., Otis Elev. Co., 260—11th Ave., New York; *for mail*, 54 Oak St., Yonkers.
BOETTGER, Robt. ('12), Pres., First Natl. Bank & Trust Co., 20 S. Broadway; *for mail*, 131 Alta Ave.
DEUTCHMAN, Julius (J'33), 1-3 Wellesley Ave.
DIEFFENBACH, Ezra C. ('30; '32; '35), 448 Hawthorne Ave.
FREE, Albert V. ('20), Sci. Dept., Saunders Tech. Sch.
GILBERT, Kenneth (J'25), Prod. Mgr., Yonkers Family Laundry, 195 Riverdale Ave., Yonkers; *for mail*, Eastview.
GOERG, Bernard ('25; '31), Research, Am. Radiator Co., 675 Bronx River Rd., Yonkers; *for mail*, 294 Bronxville Rd., Bronxville.
HINCKLEY, Chas. W. (A' 12), Asst. to Wks. Mgr., Otis Elev. Co.; *for mail*, 104 Highland Ave.
HODGE, Chas. A. ('18), Instr., City of Yonkers, 104 S. Broadway; *for mail*, 33 Seminary Ave.
HUBERT, Douglas G. (J'36), 125 Lee Ave.
JACKSON, Robt. E. (J'30), Time Study, Otis Elev. Co.; *for mail*, 355 Warburton Ave.
JENKINS, Peter ('21), Gen. Mgr., Spreckels Sugar Corp., Foot of Vark St.
KOLMORGEN, Edw. L. (J'32), Foreman, Charge Leading & Impregnating, Anaconda Wire & Cable Co., Hastings-on-Hudson; *for mail*, 241 McLean Ave., Yonkers.
McGRATH, Joseph F. ('33; '35), 265 Sedgwick Ave.
MESTON, Chas. R. ('22), 455 N. Broadway.
MOODY, Chas. F. ('24; '33), Engrg. Dept., Habirshaw Cable & Wire Corp.
NIEDERAUER, W. J. (J'35), M. E., Maint. Dept., Agfa Ansco Corp., Binghamton; *for mail*, 131 King Ave., Yonkers.
SKINNER, Halcyon N. ('13; '26), Ch. Engr., Alex. Smith & Sons Carpet Co.
SUMMERHAYES, Edw. R. (J'32), Indus. Engr., Otis Elev. Co., Yonkers; *for mail*, 455 E. 182nd St., New York.
UNGAR, J. Stephen (J'27), Asst. Testing Engr., M. E., Charge Opera., Maint. & Design, Consltd. Edison Co. of N. Y., Inc., 201st St. & 9th Ave., New York; *for mail*, 58 Belmont Ave., Yonkers.
VAN SYCKLE, A. L. ('21), Professional Bldg., 27 Ludlow St.
WIGLE, Roy A. (J'26), Owner, Royal Elec. Carpet Washing Co., 1179 Yonkers Ave.; *for mail*, 77 Crescent Pl.

NORTH CAROLINA

ASHEVILLE, Greenville Section

ANNIS, Russell K. ('23; '31), Cons. Hyd. Engr., 11 Sylvan Ave.
BOYER, Frederic Q. ('09; '13; '26), Cons. Engr., 20 N. Market St., Asheville; *for mail*, P. O. Box 5005, Biltmore.
VANDERHOOF, Arnold H. ('18), Cons. Engr., Paragon Bldg.
WADDELL, Chas. E. ('08; '07), Pres., Chas. E. Waddell & Co., 229 Arcade Bldg.

BILTMORE, Greenville Section

FULLER, Robt. B. ('31; '35), Asst. Supt., Sayles-Biltmore Bleacheries; *for mail*, 12 Ridge Rd.

BURLINGTON, Raleigh Section

ANTHONY, Robt. D. (J'33), 106 Anthony St.

CANTON, Greenville Section

HOEY, Clyde R., Jr. ('25; '35; '35), Engr., Charge Steam Distribution & Instruments, Champion Paper & Fibre Co.; *for mail*, P. O. Box 905.
KLOPP, Chas. G. ('28; '35), M. E., Champion Paper & Fibre Co.; *for mail*, P. O. Box 388.
SLEDGE, Barnett Jenkins (J'36), Engr. Design, Champion Paper & Fibre Co.; *for mail*, Canton.
WAERN, A. W. ('08), Spec. Engr., Champion Paper & Fibre Co.; *for mail*, P. O. Box 204.
WILKINSON, Jas. E. (J'36), Jr. Engr., Champion Paper & Fibre Co.; *for mail*, Box 513.

CHAPEL HILL, Raleigh Section

GROSECLOSE, Frank F. (J'29), Assoc. Prof. M. E., Univ. of N. C.; *for mail*, P. O. Box 288.
HOEFER, E. G. ('09; '30), Head Dept. M. E., Univ. of N. C.; *for mail*, 615 Park Pl.

CHARLOTTE, Charlotte Section

ATKINS, Leland G. (J'25), Supt. & Engr., Charge Plant, So. Dyestuff Corp., P. O. Box 1045.
BOLLENBACK, Alfred W. ('23; '35), Mgr. So. Branch, Air & Refrigeration Corp., Johnston Bldg.
BRANDT, Ernest H., Jr. ('21; '26; '35), Pres., Reliance Engrg. Co., Inc., 1101 Providence Rd.; *for mail*, P. O. Box 1292.
BURKHOLDER, Chas. I. ('12), V. P., Ch. Engr., Duke Power Co.
COTHRAN, James S. ('20), Mgr. & Owner, Sales Engrg., 200 S. Tryon St.; *for mail*, P. O. Box 637.
CROCKFORD, Richard H. ('23; '28; '35), M. E., Reliance Engrg. Co., Inc., Box 1292; *for mail*, 1405 Pecan Ave.
FULLER, Vernon E. (J'29), Sales Engr., Grinnell Co., Inc., 1431 W. Morehead St.; *for mail*, 616 Grandin Rd.
GARSED, Edw. T. (A'22), 1819 E. 7th St.
GLADDING, Jas. N., Jr. (J'36), Mechanics Helper, Grinnell Co., Inc., 1431 Morehead, Charlotte, N. C.; *for mail*, 1312 W. Roma, Albuquerque, New Mex.
HADNOT, Luke Richmond (J'35), c/o Wm. Mauney, Grinnell Co., Inc.
HENDERSON, Geo. T. (J'30), Research Engr., Hinde & Dauch Paper Co., Richmond, Va.; *for mail*, P. O. Box 1776, Charlotte, N. C.
HEYWARD, Theo. C. ('15; '19), Mgr., So. Office, 1408 Independence Bldg.
HOSMER, Asa ('20; '35), So. Field Mgr., Ins. Assn. of Hartford, Conn., 1218 Johnston Bldg., Charlotte, N. C.
JACKSON, F. Raymond ('17; '24; '28), Engr., Mech. Design, Duke Power Co.
LEE, Wm. S., Jr. ('30; '35), V. P., W. S. Lee Engrg. Corp., Power Bldg.
LEROY, Walter W. (J'34), Draftsman, Estimator, Salesman, Reid Hayden, Inc., P. O. Box 926; *for mail*, 1500 Kenilworth.
MARLOW, Homer L. ('27; '35), Lub. Engr., Texas Co., Only Rd. & Granby St., Norfolk, Va.; *for mail*, 628 Louise Ave., Charlotte, N. C.
MATHEWS, Newton P. (J'29), 214 W. 6th St.
MATTHEWS, Harry E. ('30), So. Mgr., Morse Chain Co.; *for mail*, 301 N. 10th St.
OLIVE, R. W. ('29; '35), Test Engr., Duke Power Co.
PEARSON, A. K., Jr. (J'36), 724 Grandin Rd.
SMITH, L. Carl (J'31), Internatl. Harvester Co., 1300 W. Moorhead St.; *for mail*, 1228 Harding Pl.
TERRELL, Edgar A. ('30), Pres. & Treas., Terrell Mch. Co., 1200 N. Church St.
WILLIAMS, Edw. E. ('24), Gen. Supt. Steam Plants, Duke Power Co.

CLINTON, Raleigh Section

BUTLER, J. C. (J'36), Opera. Hydroelec. Plant, Carolina Power & Light Co., Tillery Hydroelec. Sta., Mt. Gilead; *home address*, Route 1, Clinton.

CULLOWHEE

DUCKETT, E. J. (J'32), West. Carolina Teachers College.

DURHAM, Raleigh Section

CHAPMAN, Robt. G. (J'36), Instr., M. E., Duke Univ., College Sta.
CLARK, Albert L. (J'36), Air-Conditioning Salesman, Designer & Supvr., Odell Small Plumbing & Htg. Co., 206 E. Parrish St.
MATHEWS, Ralph T. ('30; '35; '35), Instr., M. E., Duke Univ., Durham, N. C.; *for mail*, 1004 Vaughn St., Ann Arbor, Mich.
REED, Fred'k J. ('27; '35), Instr. M. E., Duke Univ.; *for mail*, Box 263, College Sta.
SUMMERLIN, I. W. ('28; '29), Pres., Treas., Gen. Mgr., Carolina Htg. & Engrg. Co., 220 Trust Bldg.; *for mail*, Box 197.
WHITEHURST, John Clifton (J'32), Lub. Engr., Texas Co.
WILBUR, Ralph S. ('12; '16; '34), Assoc. Prof. M. E., Duke Univ.; *for mail*, Box 265, College Sta.

ENKA, Greenville Section

BAUMANN, Frank J. (J'20), Asst. Maint. Engr., Am. Enka Corp., Enka; for mail, 172 Vermont Ave., Asheville.
GILL, Jos. R. ('18), Plant Mgr., Am. Enka Corp.; *for mail*, Box 117.
KRIEK, Peter P. ('30), Ch. Engr., Am. Enka Corp.; *for mail*, 4 Lake Dr.
MORITZ, Adrianus J. L. ('30), Tech. V. P., Am. Enka Corp.
SALLEY, E. M., Jr. (J'35), Employment Mgr. & Safety Dir., Am. Enka Corp., Enka; *for mail*, 24 Westgate Rd., Asheville.
TINDALL, Whitney P. ('23; '35), Engr., Am. Enka Corp., Enka; *for mail*, 2 Brucemont Apts., Asheville.
VAN KLINK, John ('33; '35), Supt., Chem. & Spinning Depts., Am. Brake Corp.; *for mail*, P. O. Box 115.
WAYANT, Fred A. ('31), Time Study Engr., Am. Enka Corp., Enka; *for mail*, 97 Vermont Ave., Asheville.

GASTONIA, Charlotte Section

McKELVIE, Henry M. ('32; '35), Agt., Charge So. Properties, Manville Jenckes Corp., Box 459.

GOLDSBORO, Raleigh Section

HOLT, Dean R. ('29; '35), Ch. Engr., State Hospital.

GRANITE QUARRY, Charlotte Section

LYERLY, R. F. (J'34).

GREENSBORO

KELLENBERGER, Chas. D., Jr. (J'33), 1020 W. Market St.
KENYON, Van Leslie, Jr. (J'34), Turbine & Switchboard Oper., Proximity Mfg. Co.; *for mail*, 516 Tate St.
KERCHNER, Chas. E. ('23; '35), Supt. Power, Proximity Mfg. Co.; *for mail*, 23 W. 14th St., Denim Sta.

HAZELWOOD, Greenville Section
ANDERSON, Geo. F. ('25), Ch. Engr., England-Walton & Co.

HIGH POINT, Charlotte Section
DUNBAR, A. W. (J'33), Time Study Engr., Tomlinson of High Point; *for mail*, 307 E. Farris Ave.
FIDLER, Isaac ('31), Cons. Power Engr., 217 Willowbrook St.
GLADDING, Raymond D. ('24; '35), State Administrator, Emergency Conservation Work, Soil Conservation Serv., P. O. Bldg.
THOMPSON, Wm. Graeser (J'34), 605 Montlieu Ave.

KANNAPOLIS, Charlotte Section
THOMASON, Max D. (J'33), Foreman Mch. Shop, Cannon Mills Co.; *for mail*, Kannapolis.

KERNERSVILLE, Charlotte Section
GIBBS, F. O. (J'34), Engr., Charge Mchy. & Plant Maint., So. Silk Mills, Inc.; *for mail*, P. O. Box 152.

LEXINGTON, Charlotte Section
GAMEWELL, Jos. McD. ('23), Gen. Mgr., Erlanger Cotton Mills Co.

MOUNTAIN HOME, Greenville Section
VAN NESS, Frank W. ('21), Cons. Engr.

MOUNT HOLLY, Charlotte Section
SADLER, John H. ('23; '35), Supt., River Bend Sta., Duke Power Co.

MURPHY
NESBITT, Earl J. (J'34), c/o N. C. Highway & Pub. Wks. Comm., Box 153.

NEW LONDON, Charlotte Section
DOUTHIT, Judd H. (J'30).

RALEIGH, Raleigh Section
ANDREWS, Wm. J. (J'98), 105 E. North St.
MOODY, Wm. F., Jr. (J'35), 619 E. Hargett St.
RICE, Robt. B. ('26; '31; '35), Asso. Prof. of Agri. & Engrg., M. E., N. C. State College.
ROTHGEB, R. M. ('28; '31), M. E., Supvg. Plant Opera. & Bldg. Maint., State Instn. Plants, Budget Bur., Revenue Bldg.; *for mail*, 1550 Iredell Dr.
SATTERFIELD, Howard E. ('35), Assoc. Prof. M. E., N. C. State College; *for mail*, 201 Groveland Ave.
SELKINGHAUS, W. E. (J'33), Instr. M. E., N. C. State College.
STEPHENSON, A. M. (J'32), 2302 Hillsboro St.
TURNER, Frank B. (J'28), Asst. Prof., M. E. Dept., N. C. State College.
VAUGHAN, Lillian L. ('16; '21), Prof. M. E., N. C. State College, State College Sta.

ROCKY MOUNT, Raleigh Section
GORHAM, Geo. W., Jr. (J'33), Office, Planters Cotton Oil & Fertilizer Co., Cokey Rd.

SCOTLAND NECK
WALSTON, Wm. R. (J'30), P. O. Box 132.

SOUTHPORT
SMITH, Harold Baker ('21; '22; '35).

SPENCER, Charlotte Section
ERSKINE, James Harold (J'33), Asst. Supt., Buck Steam Sta., Duke Power Co.; *for mail*, Box 188.
GUNNELL, Bruce C. (J'32), Asst. M. E., Spencer Shops, Southern Ry. Sys.
McDOWELL, Willis E. ('22; '29; '35), Supt., Buck Steam Sta., Duke Power Co.; *for mail*, Box 188.

SPINDALE, Charlotte Section
SCHAFFERT, Geo. A. (J'27), Plant Engr., Stonecutter Mills; *for mail*, P. O. Box 396.

SWANNANOA, Greenville Section
PRYDE, David R. (J'30), Asheville Farm Sch.

WILMINGTON
GARDNER, Donald A. (J'30), Asst. Engr., U. S. Engrs. Office.

WINSTON-SALEM, Charlotte Section
BAHNSON, Frederic F. ('17; '23), V. P., Ch. Engr., Bahnson Co., 1001 S. Marshall St.
REECE, Risden P. ('36), Ch. Engr., R. J. Reynolds Tobacco Co.
SPEER, K. T. (J'32), 632 Holly Ave.
VANCE, Horace H. (J'33), V. P., Asst. Gen. Mgr., J. A. Vance Co., 102 Patterson Ave.; *for mail*, 100 Banner Ave.

NORTH DAKOTA

BISMARCK
VAN DYKE, Jas. R. ('30; '34), Engr., Div. of Operations, Wks. Progress Admin.; *for mail*, 723—5th St.

BOTTINEAU
SNYDER, Merton F. (J'34).

CATHAY
SHEARD, Thos. R. (J'35), Elco Dairy, R. 6, Box 1160, Portland, Ore.; *for mail*, Cathay, N. D.

FARGO
DOLVE, Robt. M. ('30), Dean Engrg., N. D. Agri. College, State College Sta.; *for mail*, 1135—5th St., N.
HALL, Lawrence B. (J'36), 1003—9th Ave., S.

VALLEY CITY
GASSMANN, John A. (J'33), Sales Mgr., R. & G. Auto Supply Co., 515—4th Ave.; *for mail*, Valley City.

OHIO

ADA
NEEDY, John A. ('19; '35), Dean, Engrg., Ohio Northern Univ.; *for mail*, 417 N. Gilbert St.

AKRON, Akron-Canton Section
ARNSTEIN, Karl ('25), V. P., Charge Engrg., Goodyear-Zeppelin Corp.; *for mail*, 817 Delaware Ave.
AUTEN, Delbert E. (J'31), M. E., Firestone Tire & Rubber Co.; *for mail*, 154 Portage Dr.
BAUGHER, Edw. J. ('29), Goodyear-Zeppelin Corp.; *for mail*, 1490 Preston Ave.
BEATTIE, Fountain C. ('26), Plant Supt., Ohio Edison Co., 47 Main North Main, Akron; *for mail*, 1203 N. River Ave., Toronto.
BONHAM, Claude F. (J'35), Designer, Star Drilling Mch. Co., 475 Washington St.; *for mail*, 2535 Robindale Ave.
BRACHT, John P. (J'36), Test Engr., Tire Div., B. F. Goodrich Co., 500 S. Main St.; *for mail*, 365 Cypress Ave.
BRUGGEMEIER, G. H. (J'33), Sales Engr., Carey Co., 803 S. High St.; *for mail*, 721 Chitty Ave.
BUCKLEY, John Harrison (J'32), Goodyear Tire & Rubber Co.; *for mail*, 760 Chalker St.
BURTON, C. L., Jr. (J'36), Y. M. C. A.
CAMP, Virgil R. (J'34), Draftsman, Dept. 3270, B. F. Goodrich Co.
CARRIER, Lanier L. (J'36), Engr., Maint. Dept., Hoover Co., N. Canton; *for mail*, 625 Wyandott Ave., Akron.
CLARK, W. L., Jr. (J'36), 1476½ W. Market St.
COOK, Herbert E. ('29), Gen. Supt., Engrg. Div., B. F. Goodrich Co., Akron; *for mail*, 335 Broad Blvd., Cuyahoga Falls.
CRAMP, Arnold P. ('22-'35), M. E., Charge Maint., Babcock & Wilcox Co., Barberton; *for mail*, 1277 Sunset View Dr., W.
DONNELL, Lloyd H. ('29), Engr., Charge Stress Analysis, Goodyear-Zeppelin Corp.
ELDRIDGE, Geo. Brooks (J'36), Training Class, Firestone Tire & Rubber Co., Firestone Park Sta.; *for mail*, 407 Y. M. C. A.
ENGLE, Daniel E. (J'27), Engrg. Dept., Firestone Tire & Rubber Co.
FIHE, John L. (J'35), M. E., Tech. Dept., B. F. Goodrich Co., 500 S. Main St.; *for mail*, Rm. 1102, Central Y. M. C. A.
FLANIGAN, Gerald P. (J'36), Draftsman, B. F. Goodrich Co., 500 S. Main St.
FREUND, Karl (J'29), Cutless Rubber Bearing Engr., B. F. Goodrich Co.; *for mail*, 925 Aberdeen St.
GOUDY, Wm., Jr. (J'35), Supvr., Matls. Prep. Dept., Firestone Tire & Rubber Co.; *for mail*, R. D. 4, Box 773A.
GRIFFIN, Fred S. ('28), Prof. M. E., Univ. of Akron.
GROVE, Willard V. (J'28), Mech. Engrg., Babcock & Wilcox Co., Barberton; *for mail*, 945 Harrison Ave., Akron.
HAHN, Stuart H. (J'28), M. E., Physical Research Dept., B. F. Goodrich Co., Akron; *for mail*, 184 Winston Rd., Fairlawn.
HOLTMAN, Kenneth S. (J'34), 283 Merriman Rd.
HUNTER, J. R. ('18; '35), Maint. Analysis, Goodyear Tire & Rubber Co., 1144 E. Market St.
JACOBI, E. B. (J'36), P. O. Box 2732, Firestone Park Sta.
JONES, Robt. Rollin ('14), Cons. Engr., 138 Mayfield Ave.
KILGORE, Robt. G. (J'32), M. E. in Devel., Firestone Tire & Rubber Co.; *for mail*, Y. M. C. A.
KIMBALL, Dexter S., Jr. (J'28), Planning Supvr., Engrg. Div., B. F. Goodrich Co., S. Main St.; *for mail*, 715 W. Market St.
LEMLEY, Benj. W. ('15 '35), Partner, Lemley & Co., 225 W. Exchange St.
MAAS, E. F. ('16), Mgr., New Devel. Design, Goodyear Tire & Rubber Co., E. Market St., Akron; *for mail*, R. D. 1, Cuyahoga Falls.
MACLACHLAN, Andrew D. ('27; '35), Devel. Engr., Mech. Goods, B. F. Goodrich Co.; *for mail*, 148 N. Portage Path.
MORRISON, Ernest L. (J'36), 2511 East Ave.
NIXON, Boris (J'34), 431 Frazier St.
PIKE, Kenneth W. ('24; '26; '35), M. E., Quaker Oats Co., Mill & Howard Sts.
QUILLIN, Gilvin (J'29), 132 N. Adolph St.
ROUNDY, E. O. (J'35), 123 Frances Ave.
SEEKINS, A. W. ('30; '35), Designer, Engr., Chem. Div., Pittsburgh Plate Glass Co., Barberton; *for mail*, 2215—25th St., S. W.
SEIB, W. A. (J'30), Asst. M. E., Quaker Oats Co., Cor. Howard & Mill St.; *for mail*, 301 Kenilworth Dr.
SHAFFER, Maurice L. (J'34), Time Study Engr., B. F. Goodrich Co., Akron; *for mail*, 1721—14th St., Cuyohoga Falls.
SHAW, Edwin C. ('90; '92), Retired; 1037—2nd National Bldg.
SMEAL, M. W. (J'33), 461 W. Waterloo Rd.
STEWARDSON, Emil E. (J'28), Charge Air Conditioning Sales & Serv., Hardware & Supply Co., 475-535 S. High St.; *for mail*, 80 W. Center St.
SUTTON, Russell I. ('20; '35), Mch. Designer, Plant Engr., Babcock & Wilcox Co., Barberton; *for mail*, 1045 East Ave., Akron.
TRAXLER, Eugene R. (J'36), Physical Testing Lab., B. F. Goodrich Co., Akron; *for mail*, 490 Hudson Rd., Stow.
TRISHMAN, Harry A. ('31; '35), Ch. Engr., Design & Constr., Adamson Mch. Co., 730 Carroll St., Akron; *for mail*, 2322—19th St., Cuyahoga Falls.
VANCE, J. Henry ('21), Cons. Engr., Akron Pure Milk Co., 278 Bowery St.; *for mail*, 402 Crosby St.
WAGNER, Paul G. (J'35), Mch. Designer, B. F. Goodrich Co., 500 S. Main St.; *for mail*, 656 Crestview Ave.
WANER, Harry E. ('23; '27), Asst. Mgr., Mch. Devel. Dept., B. F. Goodrich Co.; *for mail*, 1091 Bloomfield Ave.
WILLIAMS, Thomas R. (J'35), Squadron Exec. Training, Goodyear Tire & Rubber Co., 1144 E. Market St.
ZIMMERMAN, Carl D. ('19; '25), Ohio Edison Co.

ALLIANCE, Akron-Canton Section
BOWERMAN, Myron R. ('35), Engr., Alliance Mch. Co., Alliance; *for mail*, Homeworth.
DAVIS, O. A. ('20), Ch. Engr., Reeves Brothers Co.; *for mail*, 849 Parkway Blvd.
KELLER, Walter D. ('22), M. E., Alliance Mch. Co.; *for mail*, 1125 S. Freedom Ave.
KENDALL, E. Homer ('16; '26), Alliance Mch. Co.; *for mail*, 628 Vincent St.

ASHTABULA, Cleveland Section
CAIN, John N. ('20; '35), Loco. Engr., Pa. R. R.; *for mail*, 1512 W. 14th St.

BARBERTON, Akron-Canton Section
BOSTIC, John A. (J'36), Draftsman, Babcock & Wilcox Co., Sterling Ave., Barberton; *for mail*, 1092 E. 72nd St., Cleveland.
COREY, Fred B. ('94; '00), Plant Engr., Pittsburg Valve & Fittings Div., Pitcairn Co.
CRAIG, John S. (J'36), Apprentice Engr., Babcock & Wilcox Co., Barberton; *for mail*, Apt. 7, 57 N. Adolph Ave., Akron.
DEMAY, John A. ('21; '27; '35), Babcock & Wilcox Co.
DOWNS, J. Nelson (J'24), Designer, Babcock & Wilcox Co.; *for mail*, P. O. Box 26.
FLETCHER, Jas. ('24), Engr., Babcock & Wilcox Co.
FORREST, Jas. ('17; '35), Estimator, Babcock & Wilcox Co.
HELLER, Frederick C. (J'36), 184 N. 6th St.
HOCK, Fred'k R. (J'36), 184 N. 6th St.
HUBBELL, Geo. W. (J'21), Prod. Dept., Babcock & Wilcox Co.; *for mail*, 224 E. Tuscarawas Ave.
HUGE, Ernest C., Jr. (J'30), Engr., Research Dept., Babcock & Wilcox Co.; *for mail*, 213 Summit St.
KAIN, Edw. M. (J'36), 570 Lloyd Ave.
KUHN, Edmund W. (J'36), Jr. Engr., Hoover Co., N. Canton; *for mail*, 147 Oakwood St., Barberton.
LANGVAND, I. L. (A'09), Asst. Supt., Babcock & Wilcox Co.; *for mail*, 526 Lloyd St.
PARKER, Luther M. (J'36), Apprentice Engr., Babcock & Wilcox, Barberton, Ohio; *for mail*, 271 Sherman Ave., Lexington, Ky.
PAULY, W. C. (J'34), Barberton City Club, 290 6th St., N. W.

POPOV, N. G. (J'35), M. E., Babcock & Wilcox Co., Barberton; *for mail* Y. M. C. A., Akron.
RANSFORD, Lawrence A. ('29; '35), Erector Dept., Babcock & Wilcox Co.
RAUCH, Ralph T. (J'36), 505 Wooster Rd., W.
REALI, Chas. M. (J'36), Draftsman, Babcock & Wilcox Co., Stirling Ave., Barberton; *for mail*, 7904 Bancroft Ave., Cleveland.
SCHOESSOW, Glen J. (J'32), Engr., Charge Math. Analysis & Design, Babcock & Wilcox Co.; *for mail*, 539 W. Wooster Rd.
SEYBOLD, Eugene (J'16), Power Plant Equip., Babcock & Wilcox Co., Stirling Ave., Barberton; *for mail*, 576 Greenwood Ave., Akron.
SHIPMAN, William H. ('30; '35), Engr., Babcock & Wilcox Co., Barberton; *for mail*, 192 S. Portage Path, Akron.
SHOEMAKER, Orin H., Jr. (J'35), Draftsman & Designer, Babcock & Wilcox Co.; *for mail*, 346—3rd St., N. W.
SNYDER, Seth M., Jr. (J'36), Draftsman, Babcock & Wilcox Co.; *for mail*, 131—7th St., N. W.
STEIN, Paul J. (J'36), Apprentice Engr., Babcock & Wilcox Co., Barberton, Ohio; *for mail*, 111 W. 16th Ave., Homestead, Pa.
SWAB, Edwin M. ('28; '33; '35), Field Erector, Babcock & Wilcox Co.
TRAINER, Jas. Edw. ('19; '35), Gen. Supt., Charge Mfg., Babcock & Wilcox Co.
TRAYLER, Will A., Jr. (J'36), Engr., Training Course, Babcock & Wilcox Co.; *for mail*, 273 Newell St.
WIITANEN, Wilho (J'36), Apprentice Engr., Babcock & Wilcox Co., Barberton; *for mail*, 159 W. Center St., Akron.
WILSON, L. B. (J'32), Research Engr., Babcock & Wilcox Co.; *for mail*, 543 Robinson Ave.
WOEHL, Frank ('19; '25), Draftsman, Babcock & Wilcox Co., Barberton; *for mail*, 719 City View Ave., Akron.
WOLF, C. E. (J'32), 209½ E. Baird Ave.
YODER, D. Milton ('22; '35), Pittsburgh Plate Glass Co.; *for mail*, 527 Princeton Ave.

BEREA, Cleveland Section

WHELAN, Roderick J. ('20; '35), Pres., Ohio Nut & Bolt Co., 600 Front St.

BREWSTER, Akron-Canton Section

PATTISON, R. C. ('20), M. E., Wheeling & Lake Erie Ry. Co.

CANTON, Akron-Canton Section

BALOUGH, Chas. ('15), V. P., Gen. Mgr., Hercules Motors Corp., Halliwell Pl., S. E.
BLAW, Alex (J'31), P. O. Box 81.
BORLAND, John (J'30), Engr., Timken Roller Bearing Co.; *for mail*, 1232—16th St., N. W.
BRUGLER, M. W. (J'36), Sales Engr., Timken Roller Bearing Co., 1835 Dueber Ave.
BUCKWALTER, Tracy V. ('13), V. P., Timken Roller Bearing Co., Canton; *for mail*, 311 E. Main St., Massillon.
BURKHARDT, Chandos ('31), Draftsman, Timken Steel & Tube Co.; *for mail*, 616 Bellflower Ave., S. W.
CLINEDINST, Wm. O. (J'33), M. E., Charge Math., Timken Roller Bearing Co., Dueber Ave.
COX, Wm. P. (J'21), Ry. Engr., Timken Roller Bearing Co., 1835 Deuber Ave., S. W.
EATON, Wm. W. ('19; A'25), 817 1st Natl. Bank Bldg.
HAAGER, Paul L. (J'28), Indus. Engr., Timken Roller Bearing Co.; *for mail*, 928 Roslyn Ave., S. W.
HARRIS, Wm. A. ('04), Gen. Supt., Carnegie-Ill. Steel Corp., 1301—15th St., S. W.
HORGER, Oscar J. (J'26), Timken Roller Bearing Co.
KLINE, Paul A. (J'34), Canton Mch. Shop, Republic Steel Corp.; *for mail*, 1139—12th St., N. W.
KLINEDINST, L. M. ('29), Gen. Mgr., Indus. Div., Timken Roller Bearing Co.
MacFADYEN, F. R., Jr. (J'35), 1435 N. Market St.
MOORE, Fred'k C. ('05), Pres., Canton Forge & Axle Co., 2025 Dueber Ave., S. W.
PACA, John P. ('24; '35), Ch. Engr., Diebold Safe & Lock Co.; *for mail*, 810—25th St., N. W.
PHIPPS, Albert J. (J'36), Mfrs. Agt., Mexico Refractories Co., Mexico, Mo.; *for mail*, 521 Broad Ave., N. W., Canton, Ohio.
SANDERS, Lieut. Col. Walter C. ('17; '21; '35), Gen. Mgr., Ry. Div., Timken Roller Bearing Co., 1835 Dueber Ave.
SIEDLE, Arnold D. (J'30), Sr. Engr., Hoover Co.; *for mail*, 2512 View Court, N. W.
SMELLIE, Donald G. ('28), Ch. Engr., Hoover Co., N. Canton; *for mail*, 357—23rd St., N. W., Canton.
TREIBER, Otis D. ('25), Hercules Motors Corp.; *for mail*, 1414 Ridge Rd., N. W.

WECKSTEIN, Samson M. ('24; '35), Asst. Ch. Engr., Timken Roller Bearing Co.; *for mail*, 402—22nd St., N. W.
WOOLER, Ernest ('35), Ch. Engr., Timken Roller Bearing Co.

CHILLICOTHE, Columbus Section

POORE, Alan C. R. ('28), Ch. Engr., Charge Maint. & Design, Ross County Engr's. Office, Court House.
RHOADES, John F. ('22), Engr., Charge Design, Steam & Power, Mead Corp., S. Paint St.
RINGWALD, Elmer A. ('22; '32; '35), Designing Engr., Ashland Div., Am. Rolling Mill Co., Ashland, Ky.; *for mail*, 302 Cherry St., Chillicothe, Ohio.

CINCINNATI, Cincinnati Section

ALLEY, Kenneth Gilbert (J'35), Cincinnati Milling Mch. Co., Oakley; *for mail*, 4011 Ballard Ave.
ANDERSON, Chas. H. ('14), M. E., Pumping Dept., Cincinnati Water Wks., 2545 Eastern Ave.; *for mail*, 2886 Ziegle Ave., Hyde Park.
ARCHEA, Walter D. ('19; '35), Design Engr., Sales Serv. Dept., Cincinnati Milling Mch. Co., Oakley; *for mail*, 6621 Iris Ave.
BALDWIN, Bert L. ('90), 2529 Bell Pl.
BALLMAN, Harry C. (J'35), Sales Rep., Commercial Accts., Island Creek Coal Co., Dixie Terminal Bldg.; *for mail*, 6403 Kennedy Ave.
BARKER, Robt D. ('31; '35), Indus. Engr., Union Cent. Life Ins. Co., Vine St.; *for mail*, 3441 Custer St.
BARTELS, Herman ('27), Gen. Engrg., Steam Piping Design, Columbia Gas & Elec. Co., 323 Plum St.; *for mail*, 1275 Grace Ave.
BAUER, Jacob R. (J'28), M. E., Procter & Gamble Co., Ivorydale; *for mail*, 2615 Kipling Ave.
BEAM, Palmer H. (J'27), Htg. Engr., Sales, W. C. Green Co., 704 Race St.
BERGEN, Harold B. (A'25), Dir. Indus. Relations, Procter & Gamble Co., Ivorydale.
BIESER, Carl W. ('22; '33), Supt., Charge Mfg., Gruen Natl. Watch Case Co., E. McMillan St.; *for mail*, 3561 Raymar Blvd.
BINNS, Geo. W. ('17; '35), M. E., Consultant, Cincinnati Milling Mch. Co.
BLACKBURN, Alfred T. (J'31), Asst. Shop Supt., Cincinnati Milling Mch. Co.; *for mail*, 4017 Alston Ave.
BLACKWELL, Hubert C. ('21), Pres., Cincinnati Gas & Elec. Co., 4th & Main Sts.
BRANDT, Hugh B. ('24; '30; '35), Procter & Gamble Co.
BRAUN, John J. ('36), Factory Mgr., U. S. Playing Card Co., Norwood; *for mail*, 4305 Floral Ave., Norwood.
BRENNAN, Jas. E. ('30; '35), Engr., Cincinnati Milling Mch. Co., Marburg & South Sts.; *for mail*, 1631 Dudley St.
BRODIN, Carl O., Jr. (J'36), Cincinnati Milling Mch. Co. & Grinders, Inc., Marbury & South Sts., Oakley; *for mail*, 2844 Minot Ave., Oakley.
BROWN, Chas. A. (A'24), Secy., Asst. Gen. Mgr., Lunkenheimer Co., P. O. Box 360, Annex Sta.
BROWN, Darwin S. ('25; '35), Mgr., Elec. Prod., Charge Elec. Power Stas., Cincinnati Gas & Elec. Co., 4th & Main St.; *for mail*, 3228 Glengyle Ave.
BRUCK, Albert G. ('20; '35), M. E., Supt. Refrig. Prod., Crosley Radio Corp., Arlington St.; *for mail*, 2464 Wahl Terrace.
BUNTING, Jos. Wm. (J'28), Assoc. Prof. M. E., Univ. of Cincinnati.
BURGOYNE, Chas. Lyman (J'33), 2707 Norwood Ave., Norwood.
BURLINGAME, J. H. (A'20), Branch Mgr., West. Adjustment & Inspc. Co., 1312 Traction Bldg.; *for mail*, 3754 Andrew Ave.
CARDULLO, Forrest E. ('10), Ch. Engr., Charge Design, G. A. Gray Co., 3611 Woodburn Ave.; *for mail*, 622 Evanswood Pl.
CARLISLE, Morten ('29), Retired; 71 E. Hollister St.
CHALKEY, Curtis R. ('16; '24), Asst. Engr., Cincinnati Union Term. Co., Temple Bar Bldg., Cincinnati, Ohio; *for mail*, 40 Beechwood Rd., Ft. Mitchell, Ky.
CRAMER, Wesley G. (J'28), Cincinnati Dist. Mgr., Marley Co., Carew Tower; *for mail*, 1346 Herlin Pl.
CURTIS, Edma H., Jr. ('01; '26), Factory Supt., Nivision-Weiskopf Co., Reading; *for mail*, 8 Ridgeway Apts.
DALL, Albert H. (J'30), Engr., Cincinnati Milling Mch. Co., Oakley; *for mail*, 6846 Elwynne Dr.
DAY, Ralph R. ('20; '35), Res. Engr., Design & Constr., Sanderson & Porter, 7818 Anthony Wayne.
DeFOREST, C. W. ('22), Ch. Engr., Charge Engrg. & Design, Cincinnati Gas & Elec. Co., 312 Plum St.
DENNISTON, John B. (J'32), Procter & Gamble Co., Ivorydale; *for mail*, 1963 Avonlea Ave.
DEWEY, Fred S. ('23), 200 Hillcrest Dr., Wyoming.

DuBRUL, Ernest F. (A'00), Mgmt. Engrg., Enquirer Bldg.
EINSTEIN, Sol ('13), V. P. & Ch. Engr., Cincinnati Milling Mch. Co., Oakley.
ELFRING, John B. ('20; '35), M. E., Cincinnati Milling Mch. Co., Oakley; *for mail*, 6120 Woodmont Ave.
ERNST, Hans ('26), Research Engr., Cincinnati Milling Mch. Co., Oakley; *for mail*, 5856 Yononte Ave.
EVANS, Edw. B. (J'31), Assoc., Wood & Wood, 2801 Carew Tower.
FABERA, Wenzel (J'26), Steam Supvr., Procter & Gamble Co., Ivorydale; *for mail*, 1934 Lawn Ave.
FAIG, John T. ('97; '05), Pres., Ohio Mechanics Inst.
FIELMAN, Walter E. M. (J'25), M. E., J. H. Fielman Dairy Co., 2519 Vine St.; *for mail*, 210 Lyon St.
FOGARTY, Wm. Bailey ('31), Comdr., U. S. N., Retired, 624 Lincoln Ave.
FOSDICK, Wm. P. ('16), Partner, Fosdick & Hilmer, Cons. Engrs., 1703 Union Trust Bldg.
FOX, Chas. Hust ('00), Pres., Ahrens-Fox Fire Eng. Co., 800 Evans St.; *for mail*, 2966 Erie Ave.
FRANK, Carl F. W. (A'30), Pres., Frank Automatic Bending Co., Inc., 201 Elm St.; *for mail*, 3306 Claramont Ave.
FREEMAN, Benj. W. ('15; '25), Pres., Louis G. Freeman Co., 909 Sycamore St.; *for mail*, 2613 Handasyde.
FRESHWATER, Edmon S. (J'34), Asst. Serv. Engr., Stoker Dept., Consolidation Coal Co., 811 Race St.
FREY, Geo. J. ('22; '35), Head Dept. Mech. Drawing & Mch. Design, Ohio Mechanics Inst., Central Pkwy. & Walnut St.
GEERS, J. F. ('29), Pres., Gen. Mgr., Index Mchy. Corp., 49 Central Ave.
GEIER, Fred'k V. (A'28), Pres., Cincinnati Milling Mch. Co., Oakley.
GIBBAS, Linus J. (J'34), Maint. Engr. Kroger Grocery & Bakery Co.; *for mail*, 2625 Ashland Ave.
GRAF, Andrew J. ('30; '35), Engr., Design Supvr., Cincinnati Milling Mch. Co., Oakley; *for mail*, 3710 Darwin Ave., Cheviot.
GRAHAM, John M. (J'34), 913 Provident Bank Bldg.
GROENE, Wm. F. ('08), Ch. Engr., R. K. LeBlond Mch. Tool Co., Madison & Edwards Rds.
GROOM, J. Howard ('27; '35), Engr., Complaint & Serv. Desk, Cincinnati Milling Mch. Co., Oakley; *for mail*, 1915 Hopkins Ave., Norwood.
GRUBER, Chas. W. (J'33), Asst. Heating Survey Engr., Consolidation Coal Co., 811 Race St.; *for mail*, Montieth & Linwood Rd.
GUDMENS, H. Wm. ('27), Financial Engr., Thos. Emery Sons, Inc., Carew Tower; *for mail*, 3521 Zumstein Ave.
HAMM, Hans W. (J'34), Mch. Shop Draftsman, Am. Can Co.; *for mail*, 3455 Dury Ave.
HAMMLER, Eric ('29; '35), Div. of Bldgs., City Hall.
HANSON, Erick Lennart (J'34), 146 W. McMillan St.
HARTMANN, Carl ('21; '35), Designer, Lunkenheimer Co., Beekman St.; *for mail*, 3798 Liston Ave.
HASSMAN, Fred. A. ('30), Charge Design, Cincinnati Milling Mch. Co., Marburg & South Sts.; *for mail*, 824 Wakefield Dr.
HAZELTON, R. T. ('09; '16), Treas. & Wks. Mgr., Cincinnati Shaper Co., Hopple, Elam & Garrard; *for mail*, 2517 Observator Rd.
HEEKIN, Daniel M. ('17; '23), Secy., Treas., Heekin Can Co., 6th & Culvert Sts.
HEENA, Carl R. ('22; '25; '35), Asst. Supt., Lodge & Shipley Mch. Tool Co., 3055 Colerain Ave.; *for mail*, 6305 Edwood Ave.
HEHEMANN, Fred H. (J'14), Asst. Ch. Engr., Lunkenheimer Co.
HEILIG, Wm. ('27 '35), Engr., Charge Devel. & Research, Wm. Powell Co., 2525 Spring Grove Ave.; *for mail*, 3214 Woodburn Ave.
HICKENLOOPER, Smith, Jr. (J'36), 3448 Berry Ave.
HILMER, Otto E. ('16; '18), Partner, Fosdick & Hilmer, 1703 Union Trust Bldg.; *for mail*, 3205 W. 8th St.
HOBART, Jas. C. ('88; '93), Retired, Triumph Elec. Corp., 107-109—2nd St.; *for mail*, 4 Elmhurst Pl.
HOPPER, Saml. J. ('25), 2521 Melrose Ave., Norwood.
JOERGER, C. Albert ('22; '35), Prof. M. E., Univ. of Cincinnati.
JOHNSTON, Paul K. ('22; '26), Head of Dept. of Physics & Elec., Ohio Mechanics Inst., Walnut St. & Central Pkwy.
KEARNS, Bernard A. ('29), Designing Engr., Cincinnati Grinders, Inc.; *for mail*, 3956 Warwick Ave.

KEIFER, Boyd E. ('29), Dist. Mgr., Indus. Div., Timken Roller Bearing Co., 236 E. 9th St.
KELLY, Thos. C. ('14), Cons. M. E., 605—2nd Natl. Bank Bldg.
KIEFER, Carl J. ('20), Cons. Engr., 918 Schmidt Bldg.
KINNEY, A. M. ('35), Pres., A. M. Kinney, Inc., 1828 Carew Tower.
KINSINGER, H. B. ('30; '35), Asst. Secy. & Treas., M. Werk Co., Murray Rd., St. Bernard.
KOEHLER, Christopher L. ('19; '30), Gen. Mgr., Alvey-Ferguson Co., Inc., Oakley.
LEBLOND, Richard E. ('23; '36), Spec. Apprentice, R. K. LeBlond Mch. Tool Co., Madison & Edwards Rds.; *for mail*, 1421 Herschell Ave., Hyde Park.
LEBLOND, Richard K. ('00), Pres., R. K. LeBlond Mch. Tool Co., Madison & Edwards Rds.
LOCKEMAN, Geo. F. ('22; '28; '32), M. E., Procter & Gamble Co., Ivorydale; *for mail*, 361 Beech, Wyoming.
LOFTS, David ('01), 3904 Leugewood Dr.
MAIER, Harry ('29; '35), Engr., Charge Steel Product Design, Lunkenheimer Co.; *for mail*, 3740 Martdell Pl., Cheviot.
MANLEY, S. M. ('07; '17), Gen. Cons. Engr., Procter & Gamble Co., Ivorydale.
MARTELLOTTI, Ercole M. ('26; '35), Research Engr., Cincinnati Milling Mch. Co., Marburg & South Sts., Oakley; *for mail*, 3534 Rawson Pl., Hyde Park.
MARTIN, Edw. J. ('17; '26), Power Engr., Procter & Gamble Co., Ivorydale; *for mail*, 6122 Robison Rd.
MARX, Henry ('80; '92), Pres., G. A. Gray Co., 3611 Woodburn Ave.
MAXON, Bruce E. ('23; '30), Cons. Engr., 602 Greenwood Bldg.
McGEORGE, Gerald G. (J'35), Mech. Supvr., Procter & Gamble Co., Ivorydale.
MEHLHOPE, Lincoln E. (J'24), Estimating Engrg., Cincinnati Milling Mch. Co., Oakley; *for mail*, 5724 Wyatt Ave.
MERCHANT, M. Eugene (J'36), Research Fellow, Basic Sci. Lab., Univ. of Cincinnati; *for mail*, 2918 Jefferson Ave.
MILLER, Donald E. (J'29), Jr. Engr., Procter & Gamble Co., Ivorydale; *for mail*, 1839 Garden Lane.
MITSCH, Edw. H. ('21; '26; '35), Results Engr., Union Gas & Elec. Co.; *for mail*, 1007 Omar Pl.
MITTENDORF, Wm. ('16), Cons. Engr., 3508 Trimble Ave.
MORRIS, Thos. B. ('10; '26), Secy.-Treas., Charge Mfg., Mitchell Steel Co., Beekman St. & Fricke Rd.; *for mail*, 3047 Lischer Ave.
MORRIS, W. Stanley ('24; '32; '35), Draftsman, Lunkenheimer Co., Beekman & Waverly Sts.; *for mail*, 2907 Lehman Rd., Price Hill.
MORSE, Arthur H. ('11), Cons. Engr., Baldwin Co., Gilbert Ave.; *for mail*, 263 McGregor Ave.
MULLER, Donald C. (J'31), Estimating Engr., Alvey-Ferguson Co., Inc., Disney St.; *for mail*, 106 Malvern Pl.
MULLER, Edw. A. ('90; F'36), Manager, '24-'27; Vice-President, '27-'29; Pres., Gen. Mgr., King Mch. Tool Co., Clifton Ave. & B. & O. R. R.
NEARING, Dudley W. ('32), Sales Engr., New Departure Mfg. Co., of Bristol, Conn.; *for mail*, 3457 Manor Hill Dr., Cincinnati, Ohio.
NENNINGER, Lester F. ('16; '25; '31), Ch. Design Engr., Cincinnati Milling Mch. Co., Oakley; *for mail*, 3592 Raymar Dr.
OSTER, Eugene Arthur ('17; '20; '29), M. E., Tech. Advisor, French-Bauer, Inc., Plum & Central Pkwy.; *for mail*, 3913 Regent Ave., Norwood.
PAQUE, E. J. ('20; '21), Wks. Engr., Pollak Steel Co., 820 Temple Bar Bldg.; *for mail*, 815 Woodlawn Ave.
PARKER, Arthur R. ('17; '35), M. E., Engrg. Dept., Cincinnati Gas & Elec. Co., 323 Plum St.
PARKER, R. Starr (J'32), Plant Engr., H. H. Meyer Packing Co.; *for mail*, 2128 N. Main St.
PEASLEE, W. ('16; '23), Supt. & Dir., Cincinnati Grinders, Inc.
PELLETIER, Daniel S. ('27), Apt. E 3, 2805 Madison Rd.
PFEFFERLE, Frank H. ('23; '33), Engr., Charge Die Dept., Cincinnati Shaper Co., Hopple, Elam & Garrard; *for mail*, 1735 Laurelwood Circle.
PIERLE, Henry C. ('11), Secy. & Sales Mgr., R. K. LeBlond Mch. Tool Co.
PUGH, A. H. (A'16), Pres., A. H. Pugh Ptg. Co., 4th & Pike Sts.
RANSOHOFF, Nathan ('12; '21), Pres. & Gen. Mgr., N. Ransohoff, Inc., W. 71st St., Carthage; *for mail*, 3509 Biddle St.
REESE, Edwin W., Jr. (J'35), M. E., Charge Safety, Procter & Gamble Co., Ivorydale; *for mail*, 150 E. Mitchell Ave.
REINIGER, Eberhard M. ('32), Sales Engr., Cincinnati Milling Mch. Co. & Grinders, Inc., Cincinnati, Ohio; *for mail*, 7627 Parkview Rd., Upper Darby, Pa.
RHAME, Frank P. ('16; '19; '35), Sales Engr., Lunkenheimer Co.; *for mail*, 190 Mt. Pleasant Ave., Wyoming.
RICHARDS, Channing L. (J'34), Metal Specialty Co.; *for mail*, 3583 Reading Rd.
RICHTER, Ernst ('90), Retired; 179 La Fayette Circle.
RINDSBERG, Harry D. ('30), Mech. Supt., Charge Prod. & Maint., Cincinnati Enquirer, 617 Vine St.
RITTER, Harold P. ('25; '26), Mgr., Oberhelman Ritter Fdy. Co., 3323 Colerain Ave.
RITTER, Henry ('00), Retired; Box 368, Delhi Pike.
ROBINSON, Louis G. ('05; '13), Metallurgist, Ceramist, Louis G. Robinson Lab., 219 McFarland St.
ROLLMAN, Martin Edw. (J'32), Jr. Engr., Prod., Cincinnati Milling Mch. Co., Oakley; *for mail*, 17 E. University Ave.
ROMAINE, Millard ('22; '35), M. E., Charge Sales Engrg., Cincinnati Milling Mch. Co., Oakley.
SALKOVER, Nicholas M. (J'23), V. P. & Gen. Mgr., Queen City Steel Treating Co., 432 Oliver St.; *for mail*, 562 Glenwood Ave.
SAYRE, Richard L. (J'26), M. E., Charge Prod. & Maint., Heekin Can Co., 435 New St.
SCHAEUBLE, C. H. (J'31), Ch. Engr. of Power Sta., Andrew Jergens Co., 2535 Spring Grove Ave.; *for mail*, 1173 Cedar Ave.
SCHAUM, Paul F. (A'29), Designer, Crosley Radio; *for mail*, 6725 Windward St.
SCHUBERT, Edw. H. ('21; '25; '35), Supt., Prod. & Maint., Weir Kilby Corp., Norwood; *for mail*, 3516 Zinsle Rd.
SCHWEBEL, Edwin C. ('22; '35), Plant Mgr., Wadsworth Watch Case Co., 5th & Clay Sts., Dayton, Ky.; *for mail*, 3939 Elsmere Ave., Norwood, Cincinnati, Ohio.
SEYLER, Geo. A. ('21), Wks. Mgr., Lunkenheimer Co., Waverly & Beekman Sts.; *for mail*, 2424 Harrison Ave.
SHAFER, Arthur C. (J'24), Secy., O. J. Shafer Pattern Wks., Inc., 207 E. 6th St.; *for mail*, 3540 Holly Lane.
SHIRLEY, Harvey J. ('18; '25; '30), Ch. Engr. & Supt. of Bldgs. & Grounds, Board of Education, High School Bldg., Sherman Ave.; *for mail*, 3955 Elsmere Ave., Norwood.
SISSON, Chas. H. ('22), Engrg. Dept., Baldwin Co., Gilbert Ave. & Eden Pk.
SMITH, Reuel L. ('32; '35), Asst. Prof. M. E., Univ. of Cincinnati.
SOMOGYI, Chas. E. ('24; '35), Prod. Mgr., Cincinnati Milling Mch. Co.
SPALDING, Francis W. (J'24), M. E., Procter & Gamble Co., Ivorydale; *for mail*, 461 Riddle Rd.
SPIEHLER, Clarence H. ('24), Results Engr., Columbia Engrg. & Mgmt. Corp.; *for mail*, 323 Plum St.
SPINING, Warren P. (J'32), Sales Engr., Worthington Pump & Mchy. Corp.
STECKLER, Norbert (J'32), Engr., Design, of Fat Processing Equip., Procter & Gamble Co.
STRAUCHEN, David M. ('25), Gen. Supt., Cincinnati Milling Mch. Co., Oakley.
TANGEMAN, Walter W. (J'16), V. P., Cincinnati Milling Mch. Co., Oakley; *for mail*, 3450 Observatory Pl., Hyde Park.
TAYLOR, J. Wallace ('09; '10), Cons. Engr., 2714 Winslow Ave.
TAYLOR, Ralph L. ('27), Cons. Engr., P. O. Box 707.
TAYLOR, Robt. M. ('17; '26), Owner, Engrg. Counsellor, Robt. M. Taylor, Distributor, 211 Vine St.
THOMPSON, Henry P. ('14; '35), Pres., Henry P. Thompson Co., 704 Schmidt Bldg.
TOBEY, Julian E. ('35), Mgr., Fuel Engrg. Div., Appalachian Coals, Inc., Transportation Bldg.
TUECHTER, August H. (A'18), Pres., Cincinnati Bickford Tool Co., Oakley.
UIHLEIN, H. C. ('19; '35), Secy., Treas., Cincinnati Engrg. Tool Co., 1241 Knowlton St.; *for mail*, 704 Wakefield Dr.
VANCIL, E. Don ('29), Engrg. Dept., Cincinnati Milling Mch. Co.
VARKONY, Emerich ('27; '31; '35), Asst. Ch. Engr., Cincinnati Chem. Wks., P. O. Box 20, Evanston.
VERKAMP, Walter F. ('18; '25), Pres., Verkamp Corp., Losantiville Ave.
VINNEDGE, Earle W. ('17; '26), Dist. Sales Mgr., Worthington Pump & Mchy. Corp., 105 W. 4th St.
VOCKELL, Wm. H. (J'16), Pres., Cincinnati Engrg. Tool Co., 4659 Spring Grove Ave.
VOM LEHN, Stanley E. (J'35), Singer Sewing Mch. Co., 809 Walnut St.
WAREAM, Chas. E. ('17; '35), M. E., Sales Data Div., Am. Laundry Mchy. Co., Norwood; *for mail*, 4347 Floral Ave., Norwood.
WEBSTER, Francis L. (J'29), Sales Engr., Henry M. Wood Co., 800 Broadway; *for mail*, 1325 Cypress St.
WESCHE, B. A. ('17), B. A. Wesche Elec. Co., 1622 Vine St.
WEST, Granville H. (A'22), Gen. Inspr., Am. Laundry Mchy. Co.
WETTENGEL, Robt. T. (J'29), Ch. Draftsman, Vulcan Copper & Supply Co., 120 Sycamore St.; *for mail*, 8443 Curzon Ave.
WHITE, Merton G. ('06; '21), Sales Engr., Marlin Rockwell Corp., 132 E. Court St.; *for mail*, 2324 Park Ave.
WILLEY, Frank W. ('19), Partner, Finance & Engrg., Willey-Wray Elec. Co., 1523-7 Central Pkwy.
WOOD, Chas. E. ('16; '23), Sales Engrg. Dept., Lunkenheimer Co., Beekman & Waverly Sts.; *for mail*, 1657 Rose Pl.
YATES, Richard C. (J'33), Inspr., Hartford Steam Boiler Inspc. & Ins. Co., 1904 Carew Tower; *for mail*, 1958 Kinney Ave.

CIRCLEVILLE, Columbus Section

ANDERSON, Robt. M. ('98), Emeritus Prof. M. E., Stevens Inst., Hoboken, N. J.; *for mail*, Guilford Rd., Circleville, Ohio.

CLEVELAND, Cleveland Section

ACKER, Geo. H. ('22; '28; '35), Ch. Engr., Cleveland Worm & Gear Co., 3249 E. 80th St.
ACKERMAN, Albert A. ('17), Wks. Mgr., Osann Corp., 6402 Cedar Ave.
ADAMS, Albert C. (J'33), 224 E. 131st St.
ADAMS, Stafford (J'31), Ch. Draftsman, Charge Product Devel., Republic Steel Co., Republic Bldg.; *for mail*, 1484 Rosewood Ave., Lakewood.
ADELSON, J. S. ('34; '35), Ch. Metallurgist, Steel & Tubes, Inc., 224 E. 131st St.
ADWANY, R. K. (J'35), c/o Miss Daisy Harris, 1723 Conventry Rd.
AERNI, A. A. (J'31), 15528 Norway Ave.
ALBL, Frank O. (J'32), Shop Clerk, Grasselli Chem. Co.; *for mail*, 4966 Edgepark Ave.
ALDRICH, W. H. ('35), Supt. Power, Cleveland Elec. Illum. Co., 75 Public Sq.
ALLEN, Jos. F. (J'35), Sales Engr., Warner & Swasey Co.; *for mail*, 1171 Quilliams Rd.
ANDERSON, Gotthard E. (J'24), Cleveland Mgr., Foster Wheeler Corp., 1170 Ivanhoe Rd.
ARMSTRONG, Gordon ('22; '31), Dist. Mgr., McGraw-Hill Publ. Co., Inc., 1510 Hanna Bldg.; *for mail*, P. O. Box 3925, Shaker Sq. Sta.
ARNOLD, Geo., Jr. ('04), M. E., Cleveland Frog & Crossing Co., Bessemer Ave.; *for mail*, 3565 Lytle Rd., Shaker Heights.
AULT, E. Stanley ('21; '28; '35), Assoc. Prof. Mch. Design, Case Sch. of Applied Sci., 10900 Euclid Ave.
AVERY, Jasper W. (J'27), Res. Engr., Geo. B. Gascoigne, 1140 Leader Bldg.
BAGGALEY, Walter ('23; '35), M. E., Cleveland Dist., Austin Co., 16112 Euclid Ave.; *for mail*, 17805 S. Moreland Blvd., Shaker Heights.
BAKER, Robt. E. ('15), Secy., Treas., Arthur G. McKee & Co., 2422 Euclid Ave.; *for mail*, 18401 N. Park Blvd.
BAKER, Walter C. ('18), Life Member; M. E., 1822 Guarantee Title Bldg.; *for mail*, 18131 W. Clifton Rd., Lakewood.
BAREIS, Felix ('23; '35), Asst. Engr., N. Y. Cent. R. R., West 3d & St. Clair Aves.
BARNES, Fred'k A. ('16), Wks. Mgr., Bailey Meter Co., 1050 Ivanhoe Rd.; *for mail*, 1500 Rydal Mount Rd., Cleveland Heights.
BARNES, Harvey P. (J'36), 3584 Blanche Ave., Cleveland Heights.
BARNES, Thornton C. (J'29), M. E., Bailey Meter Co., 1050 Ivanhoe Rd.; *for mail*, 1861 Haldane Rd.
BARRETT, J. M. ('27), Mgr., Regulator Dept., Bailey Meter Co., 1050 Ivanhoe Rd.; *for mail*, 15409 Brewster Rd., E. Cleveland.
BASCOM, Thos. D. ('29), M. E., Charge Maint. & Design, Stand. Tool Co., 6900 Central Ave.
BATES, Albert Harlan ('90; '12), Sr. Mem. Firm, Bates, Golrick & Teare, Pat. Lawyers, 1125 Terminal Tower.
BECHTEL, August L. ('11; '22), Propr., A. L. Bechtel Mchy. Co., Box 3962, Shaker Sq. Sta.
BENES, Gaspar P. ('29; '31), M. E., Addressograph Corp., 1200 Babbit Rd.
BILLHARDT, Fred A. (J'34), M. E., Charge Mech. Testing, Aluminum Co. of Am., 2210 Harvard Ave.
BIRCHLER, Chas. F. (J'25), Sales Engr., Bailey Meter Co., 1050 Ivanhoe Rd.
BLISS, Philip E. (A'23), Pres., Warner & Swasey Co., 5701 Carnegie Ave.
BLUNDELL, Eustace E. ('17; '35), Pres., Mgr., Commercial Centerless Grinding Co., 6538 Carnegie Ave.; *for mail*, 3014 E. Overlook Rd., Cleveland Heights.

BODMER, Rudolph C. (J'27), M. E., Engrg. Dept., Bailey Meter Co., 1050 Ivanhoe Rd.; *for mail*, 1887 Mannering Rd.
BOWES, Thos. D., Jr. (J'35), Mathematician, Winton Eng. Corp., 2160 W. 106th St.; *for mail*, 17829 Lake Ave., Lakewood.
BOYD, Wm. Wallace ('10; '17; '35), Engr., Warner & Swasey Co., 5701 Carnegie Ave.; *for mail*, 1894 Ansel Rd.
BROOKS, F. Warren (J'26), Sr. Tester, Cleveland Elec. Illum. Co., 75 Public Sq.; *for mail*, 3026 Coleridge Rd., Cleveland Heights.
BROWN, J. Rowland ('00: '04; '09), Pres., Gen. Mgr., Reliance Gauge Column Co., 5902 Carnegie Ave.
BURRELL, E. P. ('19), Dir. of Engrg., Warner & Swasey Co., 5701 Carnegie Ave.
BYROM, Jas. L. ('23; '35), Process Engr., Natl. Carbon Co., West 76th St.
CARMAN, Edwin S. ('17), President, '21; Pres., Edwin S. Carman, Inc., 1643 Lee Rd.
CARSON, Gordon B. (J'33), Instr., M. E., Case Sch. of Applied Sci., Cleveland; *for mail*, 1720 Beaconwood Ave., S. Euclid.
CASE, Geo. S. ('17), Pres., Lamson & Sessions Co., 1971 W. 85th St.
CHADWICK, Lee S. ('99; '09), Pres., Perfection Stove Co., 7609 Platt Ave.
CHASE, Julian Dwight ('36), Sales Engr., B. F. Sturtevant Co., Hyde Park, Boston, Mass.; *for mail*, 19517 Frazier Dr., Rocky River, Cleveland, Ohio.
CHITTENDEN, Geo. I. ('24; '35), M. E., Geo. S. Rider Co., 12th fl., Marshall Bldg.
CHURCH, H. D. ('13), 2612 Guilford Rd., Cleveland Heights.
CLARK, Raymond E. (J'27), M. E., Bailey Meter Co., 1050 Ivanhoe Rd.; *for mail*, 1132 Oxford Rd., Cleveland Heights.
CODRINGTON, Geo. W. ('29), Pres., Gen. Mgr., Winton Eng. Co., 2116 W. 106th St.
CONNELLY, Wm. C. (A'15), Pres., Connelly Investment Co., 2801 N. Park Blvd.
CONRAD, Wm. A. ('22; '31), Chem. Engr., Grasselli Chem. Co.; *for mail*, 3280 W. 130th St.
CONSTAM, Alyn F. ('16; '35), Pres., Universal Constr. Co., Natl. City Bldg.; *for mail*, 10837 Hathaway Ave.
COOL, Kenneth A. (J'28), Engr., Charge Design, Serv. Recorder Co., 468 Hanna Bldg.
COPPERSMITH, Chas. W. ('26), Assoc. Prof. Engrg. Drawing, Case Sch. of Applied Sci.
CRANE, Eugene C. ('15; '22), M. E., Waste Disposal Dept., C. O. Bartlett & Snow Co., 6200 Harvard Ave.
DANFORTH, R. H. ('12), Prof. Mechanics, Materials, Case Sch. of Applied Sci., 10900 Euclid Ave.
DAUBER, Clarence A. (J'28), Steam Dept., Cleveland Elec. Illum. Co., 75 Public Sq.; *for mail*, 952 Englewood Rd., Cleveland Heights.
DAWSON, Albert ('31; '35), Socony-Vacuum Oil Co., Inc., 2846 E. 37th St., Cleveland; *for mail*, 452 Forest View Rd., Bay Village.
DAY, Russel B. (J'31), Attorney-at-Law, Keith Bldg.
DAYKIN, Irwin H. (J'29), Inspr., Hartford Steam Boiler Inspec. & Ins. Co., 311 Leader Bldg.: *for mail*, 2475 Eaton Rd., University Heights.
DEARASAUGH, J. P. ('29), Plant Engr., U. S. Aluminum Co., 2210 Harvard Ave.; *for mail*, 1940 Janet Rd., Cleveland Heights.
DEMCHAK, Albert P. (J'36), Engr., Towmotor, Inc., 1226 E. 152nd St.; *for mail*, 9813 Parkview Ave.
De VAU, Louis P. ('29; '35), Foreman, Mch. Shop & Maint., Steel & Tubes, Inc., 224 E. 131st St.
DICKEY, Paul S. ('28; '35; '35), Engr., Charge Research, Bailey Meter Co., 1050 Ivanhoe Rd.
DILLARD, Col. Jas. B. ('20), Gen. Supt., Cleveland Twist Drill Co., 1242 E. 49th St.
DOAN, T. Heberton ('28), V. P., Foote-Burt Co., 13000 St. Clair Ave.; *for mail*, 2760 Chesterton Rd., Shaker Heights.
DUDLEY, Winston M. (J'36), Instr., Case Sch. of Applied Sci., Univ. Circle.
DUNBAR, Jas. H. ('07), V. P., Grasselli Chem. Co., Rm. 1400, 629 Euclid Ave.
EINIG, Alvin B. ('12; '21; '35), Gen. Mgr., Motch & Merryweather Mchy. Co., 715 Penton Bldg.; *for mail*, 2592 Dartmoor Rd., Cleveland Heights.
EISELE, Paul T. (J'31), Indus. Engr., Warner & Swasey Co.; *for mail*, 10810 Fidelity Ave.
ELLIOTT, H. F. ('28), M. E., 724 Bulkley Bldg.
ELLIS, D. S. ('29; '35), Ch. Mech. Officer, Chesapeake & Ohio, Nickel Plate & Pere Marquette Rys., 1117 Midland Bldg.
ENGELMAN, Wm. H. ('27; '35), M. E., Dept. Pub. Utilities, Rm. 113, City Hall; *for mail*, 2184 Niagara Dr., Lakewood.
ERICKSON, Ralph E. ('32), 16000 Nelacrest Ave., E. Cleveland.
FABEL, Donald C. ('35), Prof. M. E., Fenn College, 2200 Prospect Ave.
FALLS, Eugene K. (J'32), M. E., Supvg. Maint. & Constr., Aluminum Co. of Am., 2210 Harvard Ave.
FEHR, Roy B. ('14; '19; '23), 1362 E. 139th St., E. Cleveland.
FRASER, P. Verness ('24; '35), Gen. Prod. Engr., Ohio Pub. Serv. Co., 1400 Hanna Bldg.; *for mail*, Box 693.
FREEMAN, Boaz (J'35), Central Y. M. C. A., 2200 Prospect Ave.
FREESE, C. E. (J'35), Design Engr., Van Dorn Iron Wks., 2685 E. 79th St.
FRETTER, N. F. ('36), Ch. Engr., McKinney Tool & Mfg. Co., 1688 Arabella Rd.; *for mail*, 3777 Monte Vista Dr., Cleveland Heights.
FRYER, Ross L., Jr. (J'35), 10429 Lake Ave.
GAEHR, David ('02; '09), M. E., 840 Rockefeller Bldg.
GAMMETER, Harry C. ('13), Retired, 2337 Bellefield Ave.
GEBHARDT, Wilson A. (J'35), Instr., Case Sch. of Applied Sci.
GECK, Donald P. (J'36), Warner & Swasey Co.; *for mail*, 2205 Middlefield Rd., Cleveland Heights.
GEISSBUHLER, John O. (J'35), Devel. Engr., Gen. Elec. Co., 1133 E. 152nd St.; *for mail*, 9820 Zimmer Ave.
GIBSON, Alfred E. ('32), V. P., Wellman Engrg. Co., 7000 Central Ave.
GILL, Neal F. (J'30), Jr. Tester, Cleveland Elec. Illum. Co., 75 Public Sq.; *for mail*, 16306 Sedalia Ave.
GITHENS, Thos. F. ('15; '17; '24), M. E., Cleveland Twist Drill Co., 1242 E. 49th St.
GLEESON, Francis T. ('21; '35), Mgr. of Steam Sales, Crane Co., 6215 Carnegie Ave.; *for mail*, 14534 Garfield Ave., Lakewood.
GORRIE, Harvard H. (J'27), Engrg. Dept., Bailey Meter Co., 1050 Ivanhoe Rd.; *for mail*, 1155 Erieview Rd., Cleveland Heights.
GRIGG, Jerome B. (A'29), V. P., Charge Sales, U. S. Coal Co., 700 Marion Bldg.; *for mail*, 18163 Clifton Rd., Lakewood.
GRONBACH, John H. ('27; '35), Dist. Mgr., Natl. Aluminate Corp., 6216 W. 66th Pl., Chicago, Ill.; *for mail*, 16225 Brewster Rd., E. Cleveland, Ohio.
GRONEMEYER, Geo. E. (J'32), Sales Engr., Babcock & Wilcox Co., Guardian Bldg.; *for mail*, 960 Helmsdale Rd., Cleveland Heights.
GROSSMAN, Paul R. (J'36), Apprentice Engr., Babcock & Wilcox Co., Barberton; *for mail*, 2199 W. Blvd., Cleveland.
GUNTHER, Wm. ('23; '35), 2774 E. 120th St.
HAMMOND, Harold M. ('19; '23; '35), Mgr., Sales, Engrg., Bailey Meter Co., 1050 Ivanhoe Rd.; *for mail*, 15706 Hazel Rd., E. Cleveland.
HANNON, John Jos. (J'29), M. E., Stock Engrg. Co., Penton Bldg.; *for mail*, 1771 N. Taylor Rd., E. Cleveland.
HANNUM, Chas. M. (J'32), 2287 Demington Dr., Cleveland Heights.
HAWLEY, Chas. G. ('26), Pres., Centrifix Corp., 3029 Prospect Ave.
HAZELTON, Chas. H. ('19), Gen. Supt., M. E., Charge Prod., Foote-Burt Co., 13000 St. Clair Ave.; *for mail*, 1875 Wymore Ave., E. Cleveland.
HEAVILON, E. B. (J'28), Indus. Engr., Am. Steel & Wire Co., Rockefeller Bldg.; *for mail*, 4305 W. 61st St.
HEIDLOFF, Wm. H. (J'28), Asst. Head, Constr. & Repair Dept., Grasselli Chem. Co., 2615 Independence Rd.; *for mail*, 906 Helmsdale Rd.
HELPBRINGER, J. N. ('17; '21), 3284 Hyde Park, Cleveland Heights.
HERRON, Jas. H. ('97; '05; F'36), Manager, '22-'25; Vice-President, '34-'36; President, '37; Pres., Jas. H. Herron Co., 1360 W. 3rd St.
HETHERINGTON, Lloyd E. (J'35), Time Study Engr., Am. Magnesium Corp., 2210 Harvard Ave.; *for mail*, 3108 Riverside Ave.
HIGLEY, Frank R. ('18; '25), Partner, Brockett, Hyde, Higley & Meyer, 1430 Keith Bldg.
HOFFMAN, Howard T. ('26; '35), 1331 Chardon Rd., Euclid.
HOWE, Jack L. ('15; '22; '35), Sales Rep., Otis Elev. Co., 1375 E. 6th St.
HUBBARD, Guy ('36), Assoc. Editor, Machine Design, Penton Publ. Co., 1213 W. 3rd St.; *for mail*, 3957 Riveredge Rd.
HULETT, Frank E. ('06), Hulett Engrg. Co., 4500 Euclid Ave.
HURLOCK, Clinton E. ('26; '35), 3847 North-Hampton Rd., Cleveland Heights.
ISIDIN, B. J. ('31), Engrs. Dept., White Motor Co., E. 79th St.; *for mail*, 2061 E. 77th St.
JARDINE, Frank ('22), Ch. Engr., Castings Div., Aluminum Co. of Am., 2210 Harvard Ave.
JERMY, Laurence E. ('27; '35), Editor, Machine Design, Penton Publ. Co., W. 3rd & Lakeside.
JOHNSON, Leonard T. ('21), Asst. Steam Engr., Grasselli Chem. Co., 1400 Guardian Bldg.; *for mail*, 1276 N. Lockwood Ave., E. Cleveland.
KAHN, Julius ('05), V. P., Republic Steel Corp., 3100 E. 45th St.
KASER, Arthur J. (J'33), Field Engr., Iron Fireman Mfg. Co., 3170 W. 106th St.
KELLER, Leonard F. (J'32), Engr., Stands. Dept., Gen. Elec. Co.; *for mail*, 15800 Euclid Ave., E. Cleveland.
KENTIS, Geo. E., Jr. (J'36), Estimator, Yoder Co., 5500 Walworth Ave.; *for mail*, 3351 W. 91st St.
KIEFER, Paul E. ('26; '32; '35), Field Engr., Edwin S. Carman, Inc., 1642 Lee Rd.; *for mail*, 13306 Argus Ave.
KINKEAD, Robt. E. ('27), Cons. Engr., Robt. E. Kinkead, Inc., 3441 Lee Rd.
KNOWLES, Chas. T. (J'32), 3108 Archwood Ave.
KOEHLER, Robt. H. (J'26), M. E. Sales, Bailey Meter Co., 1050 Ivanhoe Rd.; *for mail*, 11022 Wade Pk. Ave.
KOZAK, Henry (J'34), 11812 Cromwell Ave.
KRANZ, W. G. ('09), V. P., Charge Mfg., Natl. Malleable & Steel Castings Co., 10600 Quincy Ave.
KYLIN, Henrik O. (J'36), Engr., Bardons & Oliver, Inc., 1133 W. 9th St.; *for mail*, 2680 Scarborough Rd., Cleveland Heights.
LaFAVE, Lawrence V. ('31; '35), Engr., Devel., Gen. Motors Corp., Coit Rd. at E. 131st St.; *for mail*, 1214 N. Lockwood Ave., E. Cleveland.
LANGE, M. E. ('25), Ch. Sales Engr., Warner & Swasey Co., 5701 Carnegie Ave.
LANSING, Chas. B. ('27), Cons. Engr., Anisfield Bldg., Cleveland; *for mail*, Highland Rd., Gates Mills.
LAROCHE, Jos. J. (J'36), Sales-Service Engr., Bailey Meter Co., 1050 Ivanhoe Rd.; *for mail*, 2121 Westburn Rd., E. Cleveland.
LAWRENCE, Albert Donald (J'35), 15115 Lake Ave., Lakewood.
LEONHARD, Fred. J. (J'29), Prod. Dept., Cleveland Elec. Illum. Co., 75 Public Sq.; *for mail*, 2894 Huntington Rd.
LINCOLN, Jas. F. ('27), Gen. Mgr., Lincoln Elec. Co., Coit Rd. & Kirby Ave.
LINDSETH, Elmer L. (J'26), Prod. Engr., Cleveland Elec. Illum. Co., 75 Public Sq.
LITTLE, Chas. H. (A'04), Mgr., Universal Drafting Mch. Co., 407 Blackstone Bldg.; *for mail*, 2507 Stratford Rd.
LONGCOY, Grant B. ('24), Maint. Engr., Cleveland Bd. Education, E. 6th St.; *for mail*, 1215 Ramona Ave., Lakewood.
LORMOR, H. W. ('30), Wks. Mgr., Willard Storage Battery Co., 246 E. 131st St.
LOUZECKY, Paul J. (J'32), 2016 Wascana Ave., Lakewood.
LOVETT, Louis E. ('28), Cons. Engr., 202 E. 44th St., New York, N. Y.; *for mail*, 3041 Fairfax Rd., Cleveland Heights, Cleveland, Ohio.
LUCAS, H. M. ('04), Pres., Lucas Mch. Tool Co., 523 E. 99th St.; *for mail*, 2488 Marlboro Rd.
MACKENZIE, Henry A. ('29), Fuel Agt., Ohio Pub. Serv. Co.; *for mail*, Box 6058.
MAHER, Nolan W. ('23; '35), Pres., Sterling Water Treatment Co., 9101 Detroit Ave.
MAIN, Jas. M. ('25; '35), 16801 Hilliard Rd., Lakewood.
MATHER, Thos. H. ('18; '24; '35), Designing Engr., Bailey Meter Co., 1026 Ivanhoe Rd.; *for mail*, 1229 E. 125th St., E. Cleveland.
MATTHES, Max H. (A'22), V. P., Charge Sales, Firemen's Mutual Ins. Co., 1062 Union Trust Bldg.
McCABE, Frank E. ('20), Plant Mgr., Grabler Mfg. Co., 6565 Broadway.
McCARTHY, Eugene R. ('23; A'34), Sales Agent, Indus. Elec. Equip., 3099 Meadowbrook Blvd., Cleveland Heights.
McCLELLAND, Cory C. (J'13), Mgr., Cleveland Branch Office, Bailey Meter Co., 1050 Ivanhoe Rd.; *for mail*, 15848 Glynn Rd., E. Cleveland.
McCLENNAN, W. J. ('30; '35), 2340 Bellefield Rd., Cleveland Heights.
McCLURE, Chas. R. ('22; '25; '35), Sales Engr., Babcock & Wilcox Co., 1515 Guardian Bldg.
McGEE, W. A. ('20), M. E., Charge Design & Maint., N. Y. Cent. R. R. Co., 1324 W. 3rd St.
McINTOSH, D. C. ('30), 15515 Clifton Blvd., Lakewood.
McKEE, Arthur G. ('07), Pres., Engr. & Exec., Arthur G. McKee & Co., 2422 Euclid Ave.
McKEE, Willis ('20), Engr., Contr., 704 Guarantee Trust Bldg.
McNAIRY, Amos B. ('02), 810 Hanna Bldg.
MESKER, Louis H. ('12), Owner, Ch. Engr., L. H. Mesker Co., 920 Hollenden Hotel.
MITCHELL, Melvin H. (J'29), M. E., Natl. Tool Co.; *for mail*, 1425 Alameda Ave., Lakewood.
MUELLER, Carl F. (J'30), Jr. Tester, Power Plant, Cleveland Elec. Illum. Co., 75 Public Sq.; *for mail*, 2691 E. 116th St.
NESBIT, Edwin ('07), Mgr. Ch. Engr., Zinc Smelting Dept., Graselli Chem. Co.

NEWELL, Harry B. ('20), Exec. V. P., Ohio Forge & Mch. Corp., 3010 Woodhill Rd.
OBRIG, A. ('14), Sales Engr., Otis Elevator Co., 1375 E. 6th St.
ODBERT, John Turner (J'28), Sales Engr., Johnston & Jennings Co., 877 Addison Rd.
O'HART, Theo. C. ('29; AM'35), Commercial Engr., Gen. Elec. Co., Nela Park; *for mail*, 902 Caledonia Ave., Cleveland Heights.
OLDHAM, E. L. ('19; '35), Adv. Mgr., Cleveland Rock Drill Co., 3734 E. 78th St.; *for mail*, 1512 E. 118th St.
OLSON, Chas. W. ('17; '35), Supt., Horsburgh & Scott Co., 5114 Hamilton Ave., N. E.; *for mail*, 3582 Berkeley Ave., Cleveland Heights.
PARKER, Arthur La Rue ('29), Owner, Parker Appliance Co.; 17325 Euclid Ave.
PARKER, McRea ('22; '35), Dir. Business Dept., Bd. of Education, 1380 E. 6th St.; *for mail*, 2214 Delamere Dr., Cleveland Heights.
PEARSON, John Edwin (J'35), 13909 Alder St., E. Cleveland.
PECK, Eugene C. ('09), 534 Buckley Bldg.
PFANKU, Harlan D. (J'36), Draftsman, Permanent Mold. Aluminum Co. of Am., 2210 Harvard Ave.; *for mail*, 3864 W. 38th St.
PHELPS, Allen King (J'35), Jr. Designer, Perfection Stove Co., 7609 Platt Ave.
PHILLIPS, Victor B. ('17; '24), Mem. Firm, Crecelius & Phillips, also Pres., Phillips-Baker Rubber Co., 1560 Union Trust Bldg.
PIERCE, Percy E., Jr. (J'30), Shop Supt., Parsons Engrg. Corp., 6511 Cedar Ave.; *for mail*, 3866 W. 37th St.
PRIANISHNIKOFF, V. D. (J'34), Instr., M. E. & Math. Depts., Fenn College, 2200 Prospect Ave.
QUAYLE, L. A. ('15; '17), Ch. Engr., Dept. of Pub. Utilities, City of Cleveland, 205 City Hall.
RALSTON, Eldon K. (J'30), Ralston Engrg. Corp., 1697 Lee Road, Cleveland Heights.
RANDALL, Norman ('21; '35), Designing Engr., Cleveland Twist Drill Co.
REED, Kenneth W. ('27), Mech. & Indus. Engr., Cons. in Mgmt., 4614 Prospect Ave.; *for mail*, 1839 Wymore Ave., E. Cleveland.
REICHARD, H. G. ('20; '24; '35), Sales Engr., Combustion Engrg. Co., Inc., 1030 Guardian Bldg.
RESEK, Marc ('23; '25), Ch. Engr., Perfection Stove Co., 7609 Platt Ave.
RICHARDS, Earl M. ('25), Asst. to V. P., Charge Opera., Republic Steel Corp., Republic Bldg.
RICHMOND, Wm. O. (J'31), Instr., Case Schl. of Applied Sci.
RIEGELS, Olaf L. ('27), Cons. Engr., Charge Diesel Eng. Devel., Yoder Co.; *for mail*, 2064 W. 55th St.
RISS, Gustav A. (J'35), Gas Measurement Dept., E. Ohio Gas Co., 1405 E. 6th St.; *for mail*, 810 E. 99th St.
ROBERTS, Fred G. ('22; '25; '35), Engr., Natl. Carbon Co., Inc.
ROBINSON, Jack S. (J'28), Prod. Engr., Bailey Meter Co., 1050 Ivanhoe Rd.
ROBINSON, Max B. ('35), Dir. Indus. Relations, Charge Co-operative Wk. & Graduate Placement, Fenn College, 2200 Prospect St.
ROBINSON, Ward M. ('28), Robt. Heller & Associates, 1052 Union Trust Bldg.
RODGERS, Horace P. ('12; '18), Charge Sales & Design, H. P. Rodgers & Co., 528 Leader Bldg.
ROEPNACK, Alvin F. ('32), Inspr., Chicago Pneumatic Tool Co., 1241 E. 49th St.; *for mail*, 1213 E. 176th St.
ROSENBLUM, Earl S. (J'36), 2686 Wicklow Rd.
RUETENIK, Bernard P. ('13; '25), Asst. Supt. Power, Cleveland Elec. Illum. Co., 75 Public Sq.; *for mail*, 10119 Edgewater Dr.
RUPPEL, Harry W. ('25), Gen. Mgr., Cleveland Automatic Mch. Co., 2269 Ashland Rd.
SAGUE, Saml. R. (J'31), Pres. & Treas., J. B. Savage Co., 2160 Payne Ave.
SANERA, Michael E. (J'36), Ch. Draftsman, Broden Constr. Co., 11730 Harvard Ave.; *for mail*, 6010 Franklin Blvd.
SCHMID, Wm. A., Jr. (J'26), Asst. to Pres., City Ice & Fuel Co., 6611 Euclid Ave.; *for mail*, 2347 Tudor Dr., Cleveland Heights.
SCHONITZER, Rudolph I. ('29), Gen. Mgr., Reid Prdoucts Div., Stand. Products Co., 1071 Power Ave.
SCHWARTZ, Harry Adolph ('07; '13), Mgr. of Research, Natl. Malleable & Steel Castings Co., 10600 Quincy Ave.
SCOTT, Dudley H. ('29), Ch. Engr., Humphrey Co.; *for mail*, Euclid Beach Park.
SEELY, Warner (A'24), Secy., Warner & Swasey Co., 5701 Carnegie Ave.
SEITZ, Dean C. ('24), Ch. Engr., Russ Mfg. Co., W. 58th St. & Walworth Ave.
SESSIONS, Frank L. ('10), Cons. Engr., 1527 Rockefeller Bldg.
SETZLER, Paul H. (J'33), 1123 Selwyn Ave.
SHELTON, Reginald M. ('26; '35), Draftsman, Chesapeake & Ohio Ry., 1036 Midland Bank Bldg.
SHEPLER, Paul R. (J'36), M. E. Indus. Engr., Grasselli Chem. Co., 2615 Independence Rd.; *for mail*, Rm. 938, Cent. Y. M. C. A., 2200 Prospect Ave.
SMITH, Geo. Lee (J'31), Draftsman, Winton Eng. Corp., 2160 W. 106th St.; *for mail*, 10909 Fidelity Ave.
SMITH, R. R. ('20; '26; '30), M. E., Devel., Natl. Carbon Co., 11709 Madison Ave.; *for mail*, 4553 W. 214th St.
SMITH, S. Harold (J'32), 1st V. P., Smith Incubator Co., 3108 W. 121st St.
SMITH, Victor J. ('18; '35), Mech. Dept., Corrigan McKinney Steel Co., 3100 E. 45th St.; *for mail*, 321 Groveland Club Dr.
SPENCE, Hubert de L. ('30), Mgr., Dept. of Specialty Devels., Natl. Malleable & Steel Castings Co., 10600 Quincy Ave.
SPENGLER, Ralph Allen ('18; '35), Cons. Engr., 4614 Prospect Ave.
SPRENKLE, Raymond E. ('27; '28; '35), M. E., Bailey Meter Co., 1050 Ivanhoe Rd.; *for mail*, 999 Caledonia Rd., Cleveland Heights.
STAHL, John F. (J'28), V. P. & Secy., Stahl Gear & Mch. Co., 3901 Hamilton Ave.; *for mail*, 135 E. 209th St., Euclid.
STARK, Willet E. ('15; '25), Engr., Charge Air Conditioning, Bryant Heater Co., 17825 St. Clair Ave.; *for mail*, 1875 Rosemont Rd., E. Cleveland.
STEPHAN, Walter G. ('20), Pres., Treas., Stephan Co., 7016 Euclid Ave.
STEPHENS, Edw. C. ('31; '35), M. E., Cleveland Elec. Illum. Co., 75 Public Sq.
STEWART, Selden L., II (J'32), Furnace Oper., Otis Steel Co., Jennings Rd.; *for mail*, 7922 Spring Garden Rd., Parma.
STOCK, Arthur Jas. ('26; '35), M. E., Stock Engrg. Co., 438 Penton Bldg.
STROUD, E. G. ('01; '14), Pres., Cleveland Engrg. Agency Co., 2132 E. 9th St.
SWASEY, Ambrose ('80; H'16), Vice-President, '00-'02; President, '04; *A. S. M. E. Medallist*, '33; Chmn. of Bd., Warner & Swasey Co., 5701 Carnegie Ave.
TABORSKY, Robt. A. (J'35), Graduate Asst. in Mechanics Dept., Case Sch. of Applied Sci., University Circle; *for mail*, 95 E. 209th St., Euclid.
TANSLEY, L. R. ('35), Wks. Mgr., Apex Elec. Mfg. Co., 1067 E. 152nd St.
THEILMANN, Friederich (J'36), Gen. Engrg. Dept., Natl. Carbon Co.
THOMPSON, Ralph C. ('16; '35), Ch. Engr., Simplex Piston Ring Co. of Am., Inc., 1966 E. 66th St.
TORRENCE, Geo. Paull ('32), V. P. & Gen. Mgr., Rayon Mchy. Corp., 11901 Madison Ave.; *for mail*, 20001 S. Woodland Rd.
TOWNSEND, John Ernest (J'21), Student, Case Sch. of Applied Sci., 211 Abington Rd., Cleveland; *for mail*, 327—18th St., N. W., Canton.
TRESCOTT, Donald A. (J'36), Steel & Tubes, Inc., 224 E. 131st St.
TROFIMOV, Lev. A. ('36), Dir., Research & Devel., Electro Mech. Labs, Euclon Bldg., 17325 Euclid Ave.; *for mail*, 3859 Northampton Rd., Cleveland Heights.
TRUE, Laurence M. ('32; '35), Dir., Prod. Dept., Warner & Swasey Co., 5701 Carnegie Ave.; *for mail*, 2854 Brighton Rd., Shaker Heights.
TRUMBULL, Alonzo G. ('27), Ch. M. E., Advisory Mech. Com., Chesapeake & Ohio, Erie, Nickel Plate & Pere Marquette Rys., Midland Bldg.
TUVE, Geo. L. ('22; '26; '33), Prof. Heat-Power Engrg., Case Sch. of Applied Sci.
VAN HAMERSVELD, J. J. N. ('20; '31), Engr., Charge of Design, Warner & Swasey Co., 5701 Carnegie Ave.
VOSE, Fred H. ('06; '10), Prof. M. E., Case Sch. of Applied Sci., 10900 Euclid Ave.
WAECHTER, Jas. M. ('23; '26; '35), 807 E. 95th St.
WAITE, Wm. H. ('22), Sales Mgr. & Sales Engr., Browning Crane & Shovel Co., 16226 Waterloo Rd.; *for mail*, 2475 Lee Blvd.
WALES, C. Clarke ('30; '35), Ch. Engr., Otis Steel Co., 3341 Jennings Rd.; *for mail*, 11095 Lake Ave.
WALLENE, Gladys A. (J'34), Secy. to Head of Order Dept., Winton Eng. Corp., 2160 W. 106th St.; *for mail*, 17114 Ernadale Ave.
WENDSCHUH, Oscar H. (J'35), 2104 Alton Rd., E. Cleveland.
WESKE, John Robt. ('34; '35), Asst. Prof. Aerodynamics, Case Sch. of Applied Sci.
WEST, Ralph H. ('16), Pres., Treas., Gen. Mgr., West Steel Casting Co., 805 E. 70th St.
WETHERILL, Robt., Jr. ('19), Retired; Cleveland Athletic Club.
WHITE, Henry P. (J'34), 3287 Norwood Rd., Shaker Heights.
WHITLOCK, Col. Elliott H. ('01; F'36), Manager, '13-'16, Vice-President, '33-'35; Partner, Whitlock Mfg. Co., 11224 Locust Ave.
WICKENDEN, Wm. Elgin ('29), Pres., Case Sch. of Applied Sci., University Circle.
WILSON, Henry M. ('11), Sales Engr., Pittsburgh Valve, Fdy. & Constr. Co., 221 Rockefeller Bldg.; *for mail*, 2552 Overlook Rd.
WINDLE, A. E. ('18; '22; '27), Plant Engr., Kroger Grocery & Baking Co., 5700 Truscon Ave.; *for mail*, 1950 E. 93rd St.
WIRTSÉN, Ernst ('23; '27), Engrg. Dept., Natl. Acme Co.; *for mail*, 244 E. 151st St.
WOOD, Thos. J. ('26; '35), 1923 Powell Ave., Cleveland Heights.
WOOLLEY, R. E. ('19), V. P., Charge Sales & Engrg., Bailey Meter Co., 1050 Ivanhoe Rd.
WRIGHT, Daniel K. ('20), M. E., Lamp Devel. Lab., Incandescent Lamp Dept., Gen. Elec. Co., Nela Park.

COLDWATER

LATZER, J. B. (J'34), Plant Mgr., Pet Milk Co.

COLUMBIANA, Youngstown Section

BARROW, John (A'28), Treas., Mgr., Columbiana Boiler Co., 208 W. Railroad St.; *for mail*, 215 N. Elm St.

COLUMBIA PARK, Cincinnati Section

KIEWIT, Alfred L. (J'28), Columbia Park, Hamilton Co.

COLUMBUS, Columbus Section

ANDRIX, Earl R. ('09; '16; '35), Dist. Examiner of Steam Engrs., 217 State Office Bldg.; *for mail*, 1384 Lincoln Rd.
BEITLER, Saml. R. ('23; '34), Asst. Prof. M. E., Ohio State Univ.
BOYD, Jas. E. ('15), Life Member; Emeritus Prof. Mechanics, Ohio State Univ.
BROWN, Aubrey I. ('14; '21), Prof. Htg. & Vent., Ohio State Univ.
BUCHER, Paul ('21; '35), Asst. Prof. Steam Engrg., Dept. M. E., Robinson Lab., Ohio State Univ.
BUSH, Harold Montfort ('94; '05), 202 S. Princeton St.
COLLET, Leslie G. (J'36), Robinson Fellowship (M. E.), Ohio State Univ., N. High St.; *for mail*, 37 W. Tulane Rd.
CROFT, Daniel R. ('26; '33; '35), Supt., Compressor Dept., Ohio Fuel Gas Co., 99 N. Front St.
CROSS, R. C. (J'30), Fuel Engr., Battelle Memorial Inst., 505 King Ave.
DICKERSON, Harold S. ('12), Mgr., Indus. Oil Dept., Pure Oil Co., 620 E. Broad St.
DODGE, Gordon F. ('28), Engr., Spec. Design, Jeffrey Mfg. Co.
DORNBIRER, Wayne M. (J'24), Sr. Office Engr., Div. Opera., Wks. Progress Admin., 213 E. Water St., Chillicothe; *for mail*, 1251 Mooberry St., Columbus.
FAUST, H. M. ('30; '35), Research Engr., Ohio State Univ., Engrg. Exper. Sta. (Robinson Lab.), Columbus; *for mail*, 41 W. South St., Worthington.
FINNERAN, J. E., Jr. (J'36), Asst. to V. P., Charge Design, Superior Die, Tool & Mch. Co., 117 W. Frankfort St.; *for mail*, 89 S. Dawson Ave.
FOGLE, Philip A. (J'34), 55 W. Duncan St.
FRENCH, Thos. E. ('16), Prof., Engrg. Drawing, Ohio State Univ., 204 Brown Hall.
GILLIVAN, Chas. Z. ('25), Ch. Engr., Columbus Ry. Power & Light Co., 215 N. Front St.
GRISWOLD, H. L. ('36), Miller Seal Co., 50 W. Broad St.
HANEY, Glenn Earl ('35; '35), Acting Supt., Power Plant, Ohio State Univ.; *for mail*, 2005 Berkshire Rd.
HECKMAN, Loring E. ('28; '34; '35), Gas Engr., Columbia Engrg. Corp., 99 N. Front St.
HIRSCH, Gustav ('13), Cons. Engr., 209 S. 3rd St.
HITCHCOCK, E. A. ('98), Dean Emeritus, College Engrg., Ohio State Univ.; *for mail*, 348 W. 8th Ave.
JEFFREY, Robt. H. ('30), Chmn. Bd., Jeffrey Mfg. Co.
JOHNSON, Geo. Tewksbury ('14; '22), First V. P., Buckeye Steel Castings Co., 2211 S. Parsons Ave., P. O. Sta. G.
JONES, Chas. W., (J'34), 1110 Bryden Rd.
JONES, John Gething ('34; '35), Plant Engr., Capital City Products Co.; *for mail*, 110 E. California Ave.
JONES, Lloyd B. ('16), M. M., Charge Maint., 20 St. Shops, Pa. R. R. Co.
JUDD, Horace ('04; '10), Prof. Hyd. Engrg., Ohio State Univ.; *for mail*, 281—13th Ave.
KAISER, Elmer R. (J'34), Asst. Fuel Engr., Battelle Memorial Inst., 505 King Ave.

KERR, T. H. ('17; '21), V. P., Ohio Fuel Gas Co., 99 N. Front St.
LEHOCZKY, Paul N. ('28; '34; '35), Asst. Prof. Indus. Engrg., Ohio State Univ.
LIMBACHER, H. R. (J'36), Asst. Fuel Engr., Battelle Memorial Inst., 505 King Ave.
LOCKETT, Paul F. (J'32), 1415 Kenmore Rd.
LOEW, Arthur T. (J'32), 453 S. 22nd St.
MALLON, Fred'k J. (J'36), Maint., Fairmont Creamery Co., 239 W. Spring St.; *for mail*, Y. M. C. A., 40 W. Long St.
MARQUIS, Franklin W. ('08; '14), Prof. M. E., Chmn. Dept., Ohio State Univ.
McCRACKEN, Wm. C. ('15), Ch. Engr., Supt. Bldgs. & Grounds, Ohio State Univ.
MOFFAT, Geo. N. ('24; 35), Prof. Matls. of Engrg. & Mch. Design, M. E. Dept., Ohio State Univ.; *for mail*, 377 Alden Ave.
MOLNAR, Ernest (J'34), Student Engr. (Finishing Dept.), Buckeye Steel Castings Co.; *for mail*, 245 Barthman Ave.
MOORE, Richard D. (J'35), Mech. Dept., Opera., Columbus Dispatch Ptg. Co., 34 S. 3d St.; *for mail*, 390 E. Beck St.
MOORE, Thos. I. (J'34), 183 W. California Ave.
MYERS, C. O. ('30), Cons. Engr., C. O. Myers Engr. Co., 1105 Brunson Bldg.
NORMAN, Carl A. ('18), Prof. Mch. Design, M. E. Dept., Ohio State Univ.
OKEY, Perry ('16), Prop., Okey Mfg. Co., 562 Dennison Ave.; *for mail*, 765 Bryden Ave.
PURDY, John L. (J'35), Apprentice, Gen. Fdy. Training, Buckeye Steel Castings Co., Parsons Ave.; *for mail*, 2137 Waldeck Ave.
RICKETTS, R. D. (J'32), Inspr., Compressor Dept., Ohio Fuel Gas Co., 99 N. Front St.
ROBERTS, Chas. P. ('26; '35), Asst. Prof. M. E., Ohio State Univ.
ROBINSON, Chas. H. (J'26), Designer (Tools & Spec. Mchy.), Jeffrey Mfg. Co., N. 4th St.; *for mail*, 1094 E. 15th Ave.
SAMPSON, Edwin M. (J'19), Supt., Felber Biscuit Co., Grant Ave.
SECKENDORFF, E. W. ('22; '35), Asst. to Dir., Battelle Memorial Inst., 505 King Ave.; *for mail*, 2444 Southway Dr.
SHANK, J. M. (J'36), Student M. E., Gen. Elec. Co., Erie, Pa.; *home address*, 1812 Bedford Rd., Columbus, Ohio; *for mail*, 867 Napier Ave., Erie, Pa.
SHERMAN, Ralph A. ('24; '30), Fuel Engr., Battelle Memorial Inst., 505 King Ave.
STERTZBACH, H. W. ('20), Engr. Charge Design, Buckeye Steel Castings Co., 2211 S. Parsons Ave., P. O. Sta. G.
STINSON, Karl W. ('17; '26), Prof. Automotive Engrg., Ohio State Univ.
STONE, Julius F. ('17), Chmn., Bd. of Dirs., Seagrave Corp., 2000 S. High St.
SVEHLA, Jos. G. (J'32), Inspr., Grain Elev. & Flour Mills, Mill Mutuals Fire Ins. Co., 22 E. Gay St.; *for mail*, 1264 Madison Ave.
SWETTING, J. Rodney ('16; '26; '29), Supvrg. Engr., Norris & Elliott, Inc., Rm. 401, Columbian Bldg., Columbus, Ohio; *for mail*, 1109 S. Queen St., York, Pa.
THOMAS, Albert H. ('27), Pres., Buckeye Steel Castings Co., 2211 S. Parsons Ave.
TINKER, Oscar A. (J'34), Draftsman, Seagrave Corp., S. High St.; *for mail*, 137—12th Ave.
TUCKER, Robt. N. ('28; '35), Supt., Div. of Electricity, City of Columbus; *for mail*, 1520 Bryden Rd.
VETH, Noel D. (J'27), Mch. Designer, Internatl. Derrick & Equip. Co., 875 Michigan Ave., Columbus; *for mail*, Amlin.
WAGER, Robt. C. (J'36), Maint. Control, Ralston Steel Car Co., E. 5th Ave., Columbus; *for mail*, R. D. 2, Worthington.
WELCKER, W. A., Jr. ('30, '36), M. E., Battelle Memorial Inst., 505 King Ave.
WYATT, DeWitt H. ('24), Cons. Engr., 226 Northridge Rd.
WYER, Saml. S. ('04; '11), Cons. Engr., 1116 Beggs Bldg.
YOST, Saml. H. ('32; '35), M. E., Jeffrey Mfg. Co.; *for mail*, 656 Hilltonia Ave.
YOUNGER, John ('15), Prof. Indus. Engrg., Ohio State Univ.

CONNEAUT, Cleveland Section

SPRAGUE, Robt. W. (J'35), 410 Harbor St.

COPLEY, Akron-Canton Section

SHETLER, Alvin E. (J'36), M. E., Charge Molds, Dies & Exper. Wk., Seiberling Latex Products Co., 728—5th St., Barberton; *for mail*, R. D. 1, Copley.

COSHOCTON, Akron-Canton Section

GUERARD, A. S., Jr., (J'36), Jr. Hyd. Engr., Soil Conservation Serv., U. S. Dept. Agri.; *for mail*, 112 Coe Ave.
ROYER, Cecil R. (J'34), 129 N. 15th St.

CUYAHOGA FALLS, Akron-Canton Section

BUCKLEY, Alan G. (J'33), Goodyear Tire & Rubber Co.; *for mail*, 2495 Oakwood Dr., Cuyahoga Falls.
WALKER, Alex G. (J'36), M. E., Kent Mch. Co.; *for mail*, 501 Talmadge Rd., Cuyahoga Falls.
WERNER, Oscar ('23), Cons. & Devel. Engr., 115 Portage St.
YOUNG, J. Edw. (J'29), 1646—20th St.

DAYTON, Dayton Section

BARROWS, Walter I. ('30), Cons. Engr., 1169 Reibold Bldg.
BLANK, Walter E. ('28), Tool Engr., Charge Toolmaking Dept., Natl. Cash Register Co., Main & K Sts.; *for mail*, 105 Ravenwood Ave.
BUVINGER, Geo. A. ('01; '04), Retired; 971 Harvard Blvd.
CANBY, Harry B. ('04; '17), Chmn. Bd., Crawford, McGregor & Canby Co., Albany St.; *for mail*, 528 Belmont Park N.
CARMICHAEL, Andrew J. ('26), 161 Oxford Ave.
CARR, Jas. P. (J'35), 331 Grafton Ave.
CHRYST, Wm. A. ('17), Cons. Engr., Delco Products Div., Gen. Motors Corp., 329 E. 1st St.
CURTIS, W. H. ('29), Pres., Curtis Research Corp., 232 N. Findlay St.; *for mail*, 1414 Glendale Ave.
DAVIES, Chas. A. (J'30), 434 Grand Ave.
DEMING, Arthur K. (J'32), Research Engr., Airtemp, Inc., Leo St.
DRAKE, Wm. A. ('18), Propr., Drake Engrg. Co., 915 Reibold Bldg.; *for mail*, 328 Kenwood Ave.
GANO, Howell M. ('25), Asst. to Pres., Specialty Papers Co.; *for mail*, 19 Ivanhoe Ave.
GARDNER, Miss M. Elsa ('29; '35), Editor, Technical Data Digest, Air Corps, U. S. A., Materiel Div., Wright Field.
GEBHART, Henry ('19), Rep., Ry. Car Div., Edw. G. Budd Mfg. Co., Philadelphia, Pa. & Detroit, Mich.; *for mail*, Alexandersville Rd., R. F. D. 7, Dayton, Ohio.
GIBBONS, Michael J., Jr. ('17), Owner, M. J. Gibbons Supply Co., 601 E. Monument Ave.; *for mail*, 22 Oxford Ave.
GOLDBERG, Maximilian M. ('21), Cons. Engr., 339 Central Ave.
HARTMAN, Wm. ('21; '23), V. P., Charge Engrg. & Mfg., Natl. Cash Register Co., Main & K Sts.
HILL, Harry D. ('30), Master Elec. Co.; *for mail*, 118 Far Hills Ave.
KEMMER, Paul H. ('34), Capt. Air Corps, U. S. A., Dir. Structures, Aircraft Branch, Wright Field.
KIMMEL, Alfred W. ('16; '19; '35), Pres., Ready Mixed Corp., 20 Keowee St.
KNAPP, Leland G. ('17), 1033 Grand Ave.
KOTCHER, Ezra (J'28), Jr. Aero. Engr., Air Corps, U. S. A., Engrg. Sch., Wright Field.
McCORMICK, F. Howard ('31), Designing Engr., Elec. Range Div., Edison Gen. Elec. Appliance Co., 5600 W. Taylor St., Chicago, Ill.; *for mail*, 322 Volusia Ave., Dayton, Ohio.
PATCH, Earl S. ('23), V. P., Moraine Products Div., Gen. Motors Corp.; *for mail*, 143 Winding Way, R. R. 7.
POOCK, Albert F. (J'33), 1517—31 E. 3rd St.
RADVILLAS, Chas. K. (J'35), 37 Edgar Ave.
SALISBURY, John Q. ('27), Supvr., Machining & Tool Divs., Natl. Cash Register Co., Main & K Sts.
SANDFORT, John F. (J'34), 1305 Riverview Ave.
SBURLINO, Pascal ('20; '35), M. E., Natl. Cash Register Co.; *for mail*, 400 Brookside Dr.
SHARPE, Chas. E. (J'36), 261 Wroe Ave.
SIGMON, Arvil C. ('25; '36), Plant Engr., Dayton Rubber Mfg. Co.; *for mail*, 1815 Grand Ave.
SLUSHER, Harley J., Jr. (J'34), 2222 Wayne Ave.
SMITH, Edwin D. ('14), Plant Engr., Natl. Cash Register Co.
SMITH, Wm. Parker ('18; '35), Mgr., Indus. Dept., Kelso Wagner Co., 134 W. 2nd St.; *for mail*, 1230 Kemper Ave.
STEIN, Frederick Wm. ('23; '32), Foreman, Stand. Register Co.; *for mail*, 35 Wisteria Dr.
STERNER, Douglas S. (J'34), Matl. Control Dept., Frigidaire Div., Gen. Motors Corp.; *for mail*, 1305 Riverview Ave.
TATE, Benj. E., Jr. ('33), Ch. Engr., Power, Natl. Cash Register Co.
TOULMIN, Harry A., Jr. ('23), Pat. Atty., Toulmin & Toulmin, 11th Fl., Mutual Home Bldg.
TREADWELL, Burson (J'31), Time Study Engr., Natl. Cash Register Co.; *for mail*, 2922 Revere Ave.
WIGHT, Harry Collins ('17; '19), Cons. Engr., 922 Union Trust Bldg.
WILLIAMS, Frank H. (J'32), Delco-Frigidaire Conditioning Div., Gen. Motors Sales Corp.; *for mail*, 118 Maplewood Ave.
WRIGHT, Orville (H'18), The Pioneer Aviator, N. Broadway.
YEE, On K. (J'36), M. E., Frigidaire Div., Gen. Motors Corp., Morain City St.; *for mail*, 13 Proctor St.

DELAWARE, Columbus Section

TODD, Robt. H. (J'34), 195 N. Franklin St.

FINDLAY

DRIVER, Arthur ('13; '24; '35), 515½ S. Main St.
HUMPHREYS, Wm. H. (J'31), Plant Engr., Natl. Refining Co.; *for mail*, 915 Main St.
MILLER, Geo. E. ('33), Ch. Engr., Shovel Div., Buckeye Traction Ditcher Co.; *for mail*, 1620 N. Main St.

FOSTORIA, Toledo Section

STEINER, Walter A. (J'21), Asst. to Ch. Engr., Natl. Carbon Co., Inc.

FREMONT, Toledo Section

BROOKS, Henry W. ('18; '20), Cons. Engr., 1300 McPherson Blvd.

GENEVA, Cleveland Section

NOVAK, Mathew M. (J'35), R. D. 3.

GIRARD, Youngstown Section

DAVIDSON, Wm. H. (J'34), Welding Engr., Euclid Rd. Mchy. Co., Chardon Rd., Euclid, Cleveland; *for mail*, 609 Lawrence Ave., Girard.

GREENVILLE, Dayton Section

KATZENBERGER, Geo. B. (J'33), 324 Broadway.

HAMILTON, Cincinnati Section

BARTELS, Carl P. ('23; '35), Supt., Mosler Safe Co., Grand Blvd.; *for mail*, 208 Dick Ave.
BATES, Chas. J. ('13), Gen. Mgr., Fireproof Div., Mosler Safe Co., Grand Blvd.
BOYER, Fred'k G. L. ('28), Research Engr., Champion Paper & Fibre Co.
COLE, L. C. ('27), Cons. Engr., Niles Tool Wks. Co. (Gen. Mchy. Corp.)
DELGROSSO, Gerard (J'26), Draftsman, Mosler Safe Co.; *for mail*, 2646 Noble Ave.
GLASER, C. E. (J'13), 412 Eaton Ave.
GREGER, Henrik ('04; '15), Ch. Engr., Hooven-Owens-Rentschler Co., N. 3rd St.
KAHN, Bertrand B. ('18), 1st V. P., Estate Stove Co., P. O. Box 418, East Ave.
KOSKINEN, Einar T. ('18; '35), Mech. Engr., Gen. Mchy. Corp.; *for mail*, 3134 Benninghofen Ave.
KUTTER, Herman L. ('02; '07), Pres., Gen. Mgr., Black-Clawson Co., 2nd & Vine Sts.; *for mail*, R. R. 6.
KUTTER, Rudolf L. (J'35), Estimating & Sales Engr., Black-Clawson Co., 2nd & Vine Sts.; *for mail*, R. R. 6.
LOOMIS, Lieut. F. Kent (J'32), Resident Inspr. of Naval Matl., Hooven-Owens-Rentschler Co.
RANDALL, Guy B. ('22), Supt. Power, Champion Coated Paper Co.
REIMER, Clarence C. ('20; '35), 1445 E. Maple Ave.
STAEGE, Stephen A. ('17; '18), Cons. Engr., Black-Clawson Co., Hamilton, and Shartle Bros. Mach. Co., Middletown; *for mail*, 702 Main St., Hamilton.
TROWBRIDGE, Francis C. (J'89), Retired; 723 Dayton St.
WATERS, Vincent F. ('34; '35), Research Engr., Champion Paper & Fibre Co., N. "B" St.
WOOD, Augustus ('01), Cons. Engr., Niles Tool Wks. Co. (Gen. Mchy. Corp), N. 3rd St.
YINGLING, Frank B. ('17), Pres., Long & Allstatter Co., Secy., Treas., Ceramic Mchy. Co., V. P., Treas., Columbia Mch. Tool Co.; *for mail*, 701 Main St.

KENT, Akron-Canton Section

DE LAPOTTERIE, Harry ('18), Mgr., Automotive Sales, Lamson & Sessions Co., 1971 W. 85th St., Cleveland; *for mail*, 185 N. Chestnut St., Kent.
SMITH, Roy Harmon ('06; '17), V. P. & Factory Mgr., Falls Rivet Plant, Lamson & Sessions Co.

KENTON

BREIDENBACH, Paul H. (J'34), R. D. 4.
SCHUMANN, Alex. P. ('21; '35), Ohio Mch. Tool Co.

KING MILLS, Cincinnati Section

MACKEY, Guerard (J'30), Indus. Engr., Charge Indus. Engrg. Div., Peters Cartridge Div., Remington Arms Co., Inc.; *for mail*, Kings Mills.

LA CARNE, Toledo Section

TRAEGER, Chas. H. ('19; '35), Lieut.-Col. Ord. Dept., U. S. A.; *for mail*, Erie Ord. Depot.

LANCASTER, Columbus Section

BOOKER, Homer N. (J'26), M. E., Charge Mch. Design, Hocking Glass Co., W. 6th St.; *for mail,* Avondale.
KOENIG, A. C. (J'30), Engr., Charge Design, Altens Fdy. & Mch. Wks., Wheeling St.; *for mail,* 306 Park St.

LEETONIA, Youngstown Section

HOLT, Ray, G. (J'32), Plant Engr., Leetonia Tool Co., 160 Front St.; *for mail,* 88 Walnut St.
WOODWARD, John A. ('30), Mem. Firm, Woodward & Co., Cons. Engrs., Kunkel Bldg.

LIMA

FRANK, Graham M. ('35; '35), Engr., Shovel & Crane Div., Lima Loco. Wks., Inc.
GALVIN, John E. ('21), Pres., Ohio Steel Fdy. Co., P. O. Box F.
LAW, Clifford J. (J'25), 527 N. Jameson Ave.
RAUCH, John D. ('31), Cons. Engr., Shovel & Crane Div., Lima Loco. Wks., Inc.
ROUSH, Harry F. ('26), Fdy. Supt., Lima Loco. Wks., Inc.; *for mail,* 331 N. Jameson Ave.
SNYDER, Herbert W. ('17), Wks. Mgr., Lima Loco. Wks., Inc.
TOMFORD, Chas. W. (J'31), Engr., Buckeye Pipe Line Co., 137 W. North St.

LOCKLAND, Cincinnati Section

SORENSON, Lennard C. (J'32), Inspr., Philip Carey Mfg. Co., Lockland; *for mail,* 2145 Duck Creek Rd., Cincinnati.

LOCKWOOD, Youngstown Section

CROUCH, M. Lewis, Jr. (J'35).

LORAIN, Cleveland Section

CLARK, Dean (J'29), Box 98.
NULL, Clyde R. (J'36), Student Engr., Natl. Tube Co.; *for mail,* Apt. 14, 712 Broadway.

MANSFIELD, Akron-Canton Section

QUINN, Robt. P. (J'28), 117 W. 2nd St.
RAYMOND, Raymond P. ('20; '35), Mech. Supt., Mansfield Tire & Rubber Co., Newman St.; *for mail,* 235 Rae Ave.

MARIETTA, Akron-Canton Section

SCHELL, Frederic B., Jr. ('21; '28; '35), Engr., Stevenson, Jordan & Harrison, 19 W. 44th St., New York, N. Y.; *for mail,* 313—5th St., Marietta, Ohio.

MARION

BARNHART, Harry J. ('26), Engr., Charge Design, Osgood Co.; *for mail,* Box 310.
McNEIL, Merritt C. ('12), V. P., Osgood Co.; *for mail,* 610 Girard Ave.

MARTINS FERRY, Pittsburgh Section

BENNETT, B. Floyd ('28), M. M., Am. Sheet & Tin Plate Co.; *for mail,* 61 N. 3rd St.

MASSILLON, Akron-Canton Section

BUCHANAN, D. Dwight ('18; '21; '35), 9—6th St., N. E.
HEGGEM, Chas. O. ('89), Retired; 1143 Lincoln Way East.
IMPAGLIAZZO, A. M. (J'36), Engr., Charge Test Lab., Griscom-Russell Co.
McMULLEN, Geo. C. ('30), Tyson Roller Bearing Corp.
NELSON, Eric H. ('09), Gen. Wks. Mgr., Griscom-Russell Co.
PRENTICE, Henry M. (J'34), Lincoln Way East.
WOOD, Harry L. ('29; '30), Gen. Supt., Enterprise Aluminum Co.

MIDDLETOWN, Dayton Section

DAVIS, Arthur B. (J'35), Sales Correspondent, Am. Rolling Mill Co.; *for mail,* 110 Monroe St.
HAYES, M. F. ('36), Mech. Supvr., F. H. McGraw Co.; *for mail,* 115 N. Sutphin St.
HEALY, Jas. J. ('28; '35), M. E., Design & Constr., E. Wks., Am. Rolling Mill Co.; *for mail,* 126 S. Main St., Middletown.
HUDSON, Edwin B. ('30), Asst. to Ch. Engr., Am. Rolling Mill Co., Curtis St.; *for mail,* R. R. 2.
MARTIN, Russell Wm. ('31; '35), Indus. Engr., Am. Rolling Mill Co.; *for mail,* 1721 Tytus Ave.
SOOY, Walter E. ('27), Dir., Mgr., Gardner & Harvey Co.; *for mail,* 213 Kenwood Dr.

MONTPELIER

SCHWARTZ, Harry Albert ('19; '23; '35), Gen. Mgr., Montpelier Mfg. Co.; *for mail,* 307 E. Washington St.

MOUNT GILEAD

ERNST, Walter ('28; '35), Devel. Engr., Hyd. Press Mfg. Co.; *for mail,* 91 N. Main St.
McMILLIN, Frank B. ('31), Pres., Hyd. Press Mfg. Co.

MOUNT VERNON

BOWIE, Robt S. (J'35), Sales Engr., Cooper-Bessemer Corp., Sandusky St.; *for mail,* 201 E. Gambier St.
JAHNKE, Chas. B. ('25), Cooper-Bessemer Corp.; *for mail,* 931 E. High St.
REYNOLDS, R. L. (J'32), Utility Engr., Installation & Serv. Dept., Cooper, Bessemer Corp., N. Sandusky St.; *for mail,* 504½ N. Mulberry St.

NEWARK, Columbus Section

DEEGAN, Wayne (J'35), 235 W. Locust St.
FLEMING, Burritt G. (J'31), Power Engr., Florence-Wherle Stove Co.; *for mail,* 709 Maple Ave.
LUFKIN, Garland ('23; '26; '29), Gen. Mgr., Indus. Matls. Div., Owens-Ill. Glass Co.

NEW KNOXVILLE

KUCK, Kermit T. (J'34).

NEW PHILADELPHIA, Akron-Canton Section

JONES, Carl Lee (J'30), Jr. Power Engr., Ohio Power Co., W. High; *for mail,* 1009—4th St., N. W.

NILES, Youngstown Section

SCHAEFER, Fred'k R. ('11; '25), V. P. & Gen. Mgr., Niles Steel Products Co.

NORTH CANTON, Akron-Canton Section

BECKER, Bernard C. ('32), Devel. Engr., Hoover Co., N. Canton; *for mail,* 408 Fulton Rd., N. W., Canton.
BOERNGEN, Clyde H. (J'30), Ch. Inspr., Motor Dept., Hoover Co.; *for mail,* R. D. 7.
BOGER, Clair E. (J'29), Hoover Co.; *for mail,* 153 Donner Rd.
CUMMINGS, S. R. ('20; '26; '30), Dir. Labs., Hoover Co., N. Canton; *for mail,* 2516 View Court, N. W., Canton.
GOARD, Lowell L. (J'34), 317 McKinley St.
MELLEN, Wm. H. ('29), Research Engr., N. Canton Rd.
MUMMERY, C. R. ('30; '35), Sec. Head, Cleaner Research Lab., Hoover Co.; *for mail,* 606 E. Maple St.
WHITAKER, U. A. ('24; '36), Dir. of Devel. & Design, Hoover Co.

OTTAWA

ECKERT, J. S. ('28), Supt., Ohio Sugar Co.; *for mail,* P. O. Box 207.

PAINESVILLE, Cleveland Section

CAMPBELL, Alex. L. ('21), Cons. Mech. & Chem. Engr., 613 Madison Ave.
HOBBS, Jas. C. ('12; '16; '20), Supt. Power, Diamond Alkali Co.; *for mail,* 60 Wood St.
SHIE, Clifford H. ('21; '25; '35), M. E., Diamond Alkali Co.; *for mail,* 175 Park Blvd.

PERRYSBURG, Toledo Section

OBERST, Donald Anthony (J'34), Asst. Foreman, Supervision, Libbey-Owens-Ford Glass Co., Rossford; *for mail,* 118 E. Front St., Perrysburg.

PHILO

McFARLAND, Edw. H. ('17), Mgr., Ohio Power Co.

PIQUA, Dayton Section

ROSS, Carroll A. ('21; A'26), Propr., Ross Industries, 701 N. Wayne St.

POLAND, Youngstown Section

OVESEN, H. ('14; '22), Cons. Engr., Box 14.

PORTSMOUTH

FAIR, Chas. ('13), Vulcan Corp.

RITTMAN, Akron-Canton Section

GRANT, U. J. (J'28), Ch. Engr., Ohio Salt Co.; *for mail,* 18 N. 3rd St.
PRUDDEN, Orrin D. (J'36), Indus. Engr., Ohio Boxboard Co.

SALEM

EMENY, Fred'k J. ('99; '21), V. P., Charge Engrg. Sales, Deming Co.; *for mail,* 575 Highland Ave.
HUNT, Nathan C. ('34), Pres., C. B. Hunt & Son, 1913 E. State St.
KENDALL, Ernest E. (A'27), Sales Engr., Deming Co.; *for mail,* 730 Superior Ave.
MAWHINNEY, Matthew H. ('22; '30; '35), Cons. Engr., 402 Highland Ave.

SANDUSKY

MILLSPAUGH, Wm. H. ('03; '14), Pres., Centrifugal Steel, Inc., P. O. Box 547, Sandusky, Ohio; Chmn., Millspaugh, Ltd., Sheffield, 1, England.

SIDNEY, Akron-Canton Section

ABE, Philber A. ('30), Gen. Supt., Monarch Mch. Tool Co.; *for mail,* 923 Spruce St.
BICKEL, C. A. ('35), Engr., Design, Monarch Mch. Tool Co., 109 Oak St.; *for mail,* 885 Crescent Dr.
BRANDENBURG, Stanley A. (J'35), Traveling Sales Engr., Monarch Mch. Tool Co., Oak St.; *for mail,* 826 Spruce St.
WHIPP, Wendell E. ('30), V. P., Treas., Gen. Mgr., Monarch Mch. Tool Co.

SPRINGFIELD, Dayton Section

BALDENHOFER, Wm. (J'29), M. E., Devel., Thompson Grinder Co.; *for mail,* 721 Tanglewood Dr., Hills & Dales.
BAUER, Chas. L. ('00; '01), Pres. & Gen. Mgr., Bauer Bros. Co., Sheridan Ave. & Burt St.
BIGGS, Geo. A. ('23), Jas. Leffel & Co.
HARTMAN, Elmer C. (J'34), R. F. D. 1.
HOPPES, John J. ('90), Pres., Hoppes Mfg. Co.; *for mail,* 913 N. Limestone St.
HUTSEL, Lloyd E. (J'31), Draftsman, Combustioneer Div., Steel Products Engrg. Co., Dakota Ave.; *for mail,* 120 W. College Ave.
JENSEN, Marion A. ('26), Plant Engr., Crowell Publ. Co.
KRAUS, Chas. E. ('23), Engr., Springfield Mch. Tool Co., W. Southern Ave.; *for mail,* 220 S. Broadmoor Blvd.
LAFFERTY, Edw. C. (J'32), 521 N. Wittenberg Ave.
MATTISON, Edwin F. (J'31), c/o Ohio Steel Foundry Co.
McADAMS, Jos. E. ('19; '22), Pres., Steel Products Engrg. Co., Dakota Ave. & Columbia, Springfield; *for mail,* R. D. 1, New Carlisle.
MIKELS, John W. ('30), Ch. Engr., Rockaway Power Plant, Ohio Edison Co., 121 E. High St.; *for mail,* 1675 N. Limestone St.
MITCHELL, Raymond C. ('21; '35), Pres. & Gen. Mgr., Mitchell Engrg. Co., Walnut St.; *for mail,* 285 Dover Rd.
PERRY, Leon H. ('31), Designer, James Leffel & Co.; *for mail,* 138 E. 3rd St.
SCHMID, Alfred W. ('30), Tool Engr., Robbins & Myers, Inc.; *for mail,* 17½ W. Grand Ave.
SHOUVLIN, Patrick J. ('09), Pres., Natl.-Superior Co.
SMITH, Robt. Warren (J'35), M. E., E. E., Mech. Design Fans, Robbins & Myers, Inc., Lagonda Ave.
SPARKS, Albert F. ('18), Pres. & Gen. Mgr., James Leffel & Co., 426 East St.
STALEY, Paul A. ('27), Sr. Mem., Staley & Welch, 514 M. & M. Bldg.
WINKLER, Byron C. ('28; '35), James Leffel & Co.; *for mail,* 330 S. Yellow Spring St.

STEUBENVILLE, Pittsburgh Section

McGEE, Frank R. ('12), M. E., Carnegie-Ill. Steel Corp., Mingo Junction; *for mail,* 1121 Oregon Ave., Steubenville.
SPRAGUE, Harold F. (J'32), 1419 Belleview Blvd.

SWANTON, Toledo Section

BROWN, Edwin Fay ('24; '25), Wks. Mgr., Pilliod Co., Swanton; *for mail,* 3222 Kimball Ave., Toledo.

SYLVANIA, Toledo Section

FUENTE, Benjamin (J'31), Engrg. Dept., Spicer Mfg. Corp., Bennett Rd., Toledo; *for mail,* Balfour Rd., Sylvania.

TIFFIN

DUNSFORD, Jan R. ('31), Shawhan Hotel.
FRIEDMAN, John H. ('22; '35), Supt., Natl. Mchy. Co.

TOLEDO, Toledo Section

ALEXANDER, Chas. Anton ('22; '35), M. M., Woolson Spice Co.; *for mail,* 2022 Ontario St.
BELL, Frank S. (J'32), Bonus Rate Setter & Time Study, Libbey-Owens-Ford Glass Co., E. Broadway, Toledo; *for mail,* Dixie Highway, Perrysburg.
BENNETT, Harry A. ('24), V. P., Charge Mfg., Haughton Elev. & Mch. Co., 671 Spencer St.; *for mail,* 2715 Sagamore Rd.
BEVIN, Sydney ('09; '21), Chief Engr., Fiske Bros. Refining Co., 1500 Oakdale Ave.
BROOTZKOOS, Sergius D. ('21; '35), Staff Engr., E. W. Bliss Co., 1420 Hastings St.; *for mail,* The Hillcrest.
BURNSIDE, Col. M. C. ('19; '35), V. P., Sales Mgr., Great Lakes Air Conditioning Corp., 2314 Monroe St.; *for mail,* 1505 Jefferson Ave.
CARTER, Henry W. ('92; '03), Counsel, Owens-Ill. Glass Co., 965 Wall St.
CHEETHAM, Jos. H. ('13; '17; '35), 14 Proctor Pl.
CLOSS, Geo. M. (J'24), Plant Engr., Toledo Refinery, Sun Oil Co.; *for mail,* 3036 Hopewell Pl.

DEAN, Sidney (J'36), Indus. Engr., Libbey Glass Mfg. Co., Ash St.; *for mail*, 2338 Eastbrook Dr.
DE CORIOLIS, Ernest G. ('21), Research Dir., Surface Combustion Corp., 2375 Door St.
DORMAN, Neal W. ('13; '22), Ch. Engr., Toledo Mch. & Tool Co., Door & Hastings St., Toledo; *for mail*, 5758 Adelaide Rd., W. Toledo.
EELES, Chas. C. (J'29), Indus. Engr., Ohio Fuel Gas Co., 231 Huron St.
EMERY, Jas. R. ('21; '35), V. P., Froehlich & Emery Engrg. Co., 410—2nd Natl. Bank Bldg.
FARMER, Edw. H. (J'30), Prod. Mgr., Toledo Mch. & Tool Co.; *for mail*, 3438 Darlington Rd.
FELTHAM, Douglas L. ('22; '35), 2043 Upton Ave.
FRAUTSCHI, Carl (J'36), Designer, Conklin Pen Co., Factories Bldg.; *for mail*, 2321 Vermont Ave.
FREED, Loring ('19; '21; '35), Designer & Gen. Engrg. Wk., Swartzbaugh Mfg. Co., 1336 W. Bancroft St.; *for mail*, 2516 Drummond Rd.
FROEHLICH, Fred'k H. ('22), Pres., Froehlich & Emery Engrg. Co., 410—2nd Natl. Bank Bldg.
GILLETT, John ('20), Secy.-Treas., M. E., Mills-Rhines-Bellman & Nordhoff, 518 Jefferson Ave.
HALLENBECK, Geo. E. ('08), V. P., Gen. Mgr., Baker Bros., Inc., Post & Westlake; *for mail*, 2702 Parkwood Ave.
HAPPEL, Albert W. ('28), Cons. Engr., Kent Owens Mch. Co., 958 Wall St.; *for mail*, 2229 Grantwood Dr.
HEM, H. O. ('09), Ch. Engr., Toledo Scale Co.; *for mail*, 3009 Kenwood Blvd.
HILL, Rowland F. ('14; '23), Pat. Engr., Natl. Supply Co.; *for mail*, 1951 Richmond Rd.
KERR, Henry H. ('25), Supt. Elec. Opera. Dept., Toledo Edison Co., Edison Bldg.; *for mail*, 2365 Barrington Dr.
KIRSCH, Carl W. ('30; '35), Plant Engr., Dura Co., 4500 Detroit Ave.; *for mail*, 114—21st St.
KISER, Lee (J'31), 1661 Cone St.
KRANICH, Henry O. ('36), Plant Engr., Libbey-Owens-Ford Glass Co., E. Broadway; *for mail*, 4621 Overland Pkwy.
MARKER, Roland H. (J'21), Engr., Charge Design, Froehlich & Emery Engrg. Co., 410—2nd Natl. Bank Bldg.
MASON, O. F. ('30; '35), Engr., Charge Sales, Mason Equip. Co., 1316 Adams St.; *for mail*, 3735 Bowan Rd.
McBEE, Edgar L. ('34), Supt. Power Prod., Toledo Edison Co., 420 Madison Ave.
MIDDLETON, Leslie H. ('36), Ch. Engr., Elec. Auto-Lite Co.
NICKEL, Alfred A. (J'35), Gen. Budget Dept., Owens-Ill. Glass Co.
OHLER, Norman R. (J'35), Mech. Drive Layout, Surface Combustion Corp., 2375 Dorr St.; *for mail*, 1614 Gilbert Rd.
PALMER, Delos M. ('31; '35), Head of M. E. Dept., Univ. of City of Toledo, Toledo; *for mail*, 3825 Indian Rd., Ottawa Hills.
POMEROY, Chas. R. ('21; '35), Mch. Designer, Toledo Mch. & Tool Co., Dorr & Hastings Sts.; *for mail*, 4213 Westway St.
RATHBUN, Edward ('08), V. P., Rathbun-Jones Engrg. Co.
ROBBINS, Irving P. (J'32), M. E., Charge Results of Opera., Div. of Water, Broadway Pumping Sta., City of Toledo, 2100 Broadway; *for mail*, 3351 Blanchard St.
SCHULTZ, Oswald C. ('27; '34), Supt., Charge Prod., Natl. Superior Co.
SCHWEINHAGEN, Erwin A. (J'29), 135 Austin St.
SEAMAN, Jos. ('28; '35), Shop Supt., Haughton Elev. & Mch. Co., 671 Spencer St.; *for mail*, 2326 Barrington Dr.
SHAFFER, Jos. C. (J'35), Box 454, Bay Shore Rd.
SPICER, Clarence W. ('13), V. P., Spicer Mfg. Corp., 4100 Bennett Rd.
WEAVER, Ernest W. ('20; '26), Asst. Ch. Engr., Surface Combustion Corp., 2367 Dorr St.; *for mail*, 1622 Potomac Dr.
WINTER, Otto W. ('29; AM'35), Indus. Engr., Kent Owens Mch. Co., 958 Wall St.
ZAROBSKY, Ivan F. ('22; '25), Assoc. Prof. M. E., Univ. of City of Toledo.

TROY, Dayton Section

COPPOCK, Robt. K. (J'31), Time Study, Hobart Mfg. Co., Pennsylvania Ave.; *for mail*, 524 S. Plum St.
HOUSER, F. Douglass (J'29), Devel. Dept., Hobart Mfg. Co.
KELLY, E. Mackin (J'32), Tool Engr., Hobart Mfg. Co.; *for mail*, 517 E. Franklin St.
MILLER, F. Robt. ('23), Tool Engr., Hobart Mfg. Co.; *for mail*, P. O. Box 332.
PASCHALL, A. L. ('23), Ch. Designer, Hobart Mfg. Co.; *for mail*, 514 McKaig Ave.
RATAICZAK, T. F. ('21), Ch. Engr., Hobart Mfg. Co., Pennsylvania Ave.; *for mail*, 408 Grant St.

WADSWORTH, Akron-Canton Section

BELTZ, Geo. W. (J'34), R. F. D. 2.
GILBERT, Chas. Fred'k ('27; '35), 190 Highland Pl.

WALDO

WESTON, Clarence B. ('26), Retired; R. F. D. 1.

WARREN, Youngstown Section

BROWN, Albert ('22; '35), Combustion & Utility Engr., Warren Wks., Republic Steel Corp.; *for mail*, 736 Hall Ave., N. W.
McBERTY, Don R. ('34; '35), Designer, Republic Steel Corp; *for mail*, 431 Roselawn Ave., N. E.
WEAN, Raymond J. ('28), Pres., Wean Engrg. Co., Inc., 2nd Natl. Bldg.

WEST CARROLLTON, Dayton Section

GILLIGAN, Frank B. ('23), M. E., Oxford Miami Paper Co.

WILLOUGHBY, Cleveland Section

HESTER, E. Gorham (J'34), 2 Oakdale St.

WOOSTER, Akron-Canton Section

KUTHE, Chas. H. (J'32), 233 Pearl St.

WORTHINGTON, Columbus Section

FITZ, Ervin M, ('01; '16), Retired; 58 South St., E.

YOUNGSTOWN, Youngstown Section

BLETSO, Berne A. (J'36), Designer, Republic Rubber Co., Albert St.; *for mail*, 119 McKinley Ave.
CARNEGIE, Andrew ('21; '35), Supt. Prod., Ohio Edison Co., Akron; *home address*, 152 Brookline Ave., Youngstown.
COOMBS, Robt. R. (J'35), Asst. Steam Engr., Carnegie-Ill. Steel Corp.; *for mail*, 601 Cohasset Dr.
GEORGE, Jerome Rowley ('99), Pres., Aetna-Stand. Engrg. Co., 275 W. Federal St.
GOGA, Geo. F. (J'25), Engr., Plant Layout & Gen. Engrg., Carnegie-Ill. Steel Corp.; *for mail*, P. O. Box 706.
HAMILTON, John R. (A'14), Pres., "Automatic" Sprinkler Corp. of Am., Jones & Brittain Sts.
JONES, Jas. D. ('21), Ch. Engr., Youngstown Sheet & Tube Co.; *for mail*, Boardman-Canfield Rd., R. F. D. 4.
JONES, Lewis ('15), Exper. Engr., McKay Mch. Co., Rayen Ave.
KERR, Wallace Ed. ('29; '35), Salesman, Aetna-Stand. Engrg. Co.; *for mail*, 310 W. Madison Ave.
KIMBERLIN, Paul H. (J'30), Engr., Steam Engrg. Dept., Ohio Wks., Carnegie-Ill. Steel Corp., Youngstown; *for mail*, Box 54, McDonald.
KLINE, Lee A. (J'26), Engr., Charge Combustion & Test Wk., Ohio Wks., Carnegie-Ill. Steel Corp., Youngstown; *for mail*, R. F. D. 1, Niles.
KLING, Fred E. ('29), Ch. M. E., Carnegie-Ill. Steel Corp.; *for mail*, 2240 Selma Ave.
LINDEMUTH, F. L. ('14; '23), 236 Norwood Ave.
LORANGE, John O. (J'34), Spec. Engr., Blast Furnace Dept., Ohio Wks., Carnegie-Ill. Steel Corp., Youngstown; *for mail*, 34 W. Park Ave., Columbiana.
LUNDGREN, Iver H. (J'34), Draftsman, Republic Steel Corp., 8th St., N. E., Canton; *for mail*, 1420 Wick Ave., Youngstown.
MARPLE, Paul Gilbert (J'35), Opera. Devel. Dept., Republic Steel Corp., Market St.
McHUGH, A. G. ('34), Asst. Ch. Engr., Youngstown Sheet & Tube Co.
MEANY, Edw. A. (J'20), Sales Engr., Youngstown Metal Products Co., W. Federal St.; *for mail*, 436 Mistletoe Ave.
OHMER, Paul H. (J'36), Asst. Steam Engr., Carnegie-Ill. Steel Corp.; *for mail*, 215 E. Chalmers Ave.
OYEN, Erling O. ('34), M. E., Youngstown Sheet & Tube Co.; *for mail*, 4014 Southern Blvd.
PUGH, Geo. A. (J'19), Cons. Engr., Steel Car Forge Bldg., Ellwood City, Pa.; *for mail*, 4845 Oak Knoll Dr., Youngstown, Ohio.
REINECKE, Herman H. ('23; '35), Commercial Shearing & Stamping Co., Youngstown, Ohio; *for mail*, 220 Case Ave., Sharon, Pa.
ROBINSON, C. Snelling ('00), V. P., Youngstown Sheet & Tube Co.; *for mail*, 840 Old Furnace Rd.
SIEMON, Wm. A. (J'29), Steam Engrg. Dept., Carnegie-Ill. Steel Corp.; *for mail*, 23 Clifton Dr.
SMITH, Howard W. ('92; '18), Ch. Engr., Aetna-Stand. Engrg. Co., Youngstown, Ohio; *for mail*, Box 545, Ellwood City, Pa.
SMITH, Robt. M. ('13), Supt. Steam Plants, Youngstown Sheet & Tube Co.; *for mail*, 2559 Mt. Vernon Ave.
STAMM, J. Duncan (J'32), Time Study Engr., Effic. Dept., Youngstown Sheet & Tube Co., Campbell Wks.; *for mail*, 17 No. Champion St.
TAYLOR, Clarence L. ('04), V. P., Charge Engrg., Aetna-Stand. Engrg. Co., 275 W. Federal St.; *for mail*, 2007 Volney Rd.
WICK, Jas. L., Jr. ('32), Pres., Gen. Mgr., Falcon Bronze Co., 218 S. Phelps St.
WILLS, Christian A. ('31), Gen. Mgr., Wm. B. Pollock Co.; *for mail*, 60 W. Princeton Ave.

ZANESVILLE

CONDRON, Mark M. ('30; '35), P. O. Box 322.
GREER, Everett S. ('21; '35), Mgr., Plant 2, Hazel-Atlas Glass Co.
HOLLINGSWORTH, W. Vincent ('30), War Dept., U. S. Engrs.; *for mail*, 130 N. 7th St.
McCOY, Wm. ('03; '25), V. P., Gen. Mgr., Stand. Title Co., Maysville Ave.; *for mail*, 634 Adair Ave.
RODENBAUGH, Donald Irvin (J'32), Asst. Engr., Charge Design, Kearns-Gorsuch Bottle Co., Market St.

OKLAHOMA

AGRA, Mid-Continent Section

MILLER, A. D. (J'35), P. O. Box 366.

AVANT, Mid-Continent Section

GIVENS, Homer Chas. ('29; AM'35), Ch. Engr., Charge Natural Gas & By-Products Plant, Shell Petroleum Corp., Shell Bldg., St. Louis, Mo.; *for mail*, Box 74, Avant, Okla.

BARTLESVILLE, Mid-Continent Section

BLADES, Roger T. (J'35), Draftsman, Phillips Petroleum Co.
DOLEZAL, Edw. (J'31), 507 Creek.
HORNE, Albert N. ('30), Gen. Supt., Empire Pipe-line Co.
MEADE, Leonard P. (J'32), Engrg. Dept., Phillips Petroleum Co.; *for mail*, 1024 Jennings Ave.
SEARS, H. T. ('20; '33), Engr., Charge Design, Phillips Petroleum Co.
SIMONSON, Howard E. (J'36), 911 Dewey Ave.
WYNN, Frank C. (J'33), 706 Osage St.

CHICKASHA, Mid-Continent Section

JAMES, G. D. (J'36), Supvg. Engr., Charge Design & Constr., Soil Conservation Serv.; *for mail*, 1623 S. 17th St.
SPEARS, Jas. Barry (J'34), 928 S. 18th St.

CYRIL, Mid-Continent Section

BROWN, Harry A. (J'34), Jr. Engr., Anderson-Pritchard Oil Co.; *for mail*, Box 253.

DRUMWRIGHT, Mid-Continent Section

ROMBERG, Gibson S. (J'36), Box 1131.
TRANSOU, Adam J. (J'36), Jr. Engr., Mech. Dept., Tidewater Oil Co.

GRANDFIELD, Mid-Continent Section

YOUNG, Rex ('32; '35), Gen. Supt. Refinery, Bell Oil & Gas Co.

LAWTON, Mid-Continent Section

ARMSTRONG, Lawrence H. (J'36), Gas Engr. & Draftsman, Southwest. Light & Power Co.; *for mail*, 905 "A" Ave.

NORMAN, Mid-Continent Section

BECK, H. V. (J'30), Asst. Prof. M. E., Univ. of Okla.
BLODGETT, Donald E. (J'36), 746 De Barr.
CARSON, W. H. ('31), Prof., Dir. Sch. of M. E., Univ. of Okla.
FELGAR, J. H. ('16), Dean, College of Engrg., Univ. of Okla.

OKLAHOMA CITY, Mid-Continent Section

BANDELIER, Geo. E. ('29; '35), Asst. State Engr. Inspr., Okla., Pub. Wks. Admin., 318 Key Bldg.; *for mail*, 2738 N. W. 16th St.
BLAKE, Joel W. ('34; '35), M. E., Generation Dept., Okla. Gas & Elec. Co., 3rd & Harvey; *for mail*, 825½ East Dr.
FEAGLES, Ralph L. ('12), Engr., Charge Patents, Black Sivalls & Bryson, Inc., 2131 Westwood St.
HALLIDAY, John L. (J'36), Jr. Engr., Maint., New State Ice Co., 16 W. 2nd St.; *for mail*, 17 Highland Circle.
HOWARD, Otis ('26; '29), Asst. Gen. Supt. Opera., Okla. Gas & Elec. Co., 321 Harvey St.
HUNTER, Ernest E. ('27), Supt. Generation, Okla. Gas & Elec. Co., 319 N. Harvey St.
MAYES, Curtis (J'36), Natl. Supply Co.; *for mail*, 1117 W. 34th St.
RAYMOND, G. ('30), Ch. Engr., Black Sivalls & Bryson, Inc., Box 1377; *for mail*, 2039 W. 18th St.
SHERMAN, Warren S. ('22; '24), Pres., Sherman Mch. & Iron Wks., 18 E. Main St.
STUEVE, Winfred ('30), M. E. Charge Oil Field Power Sales, Okla. Gas & Elec. Co.
TAUSON, P. O. (J'35), Engr., 1739 N. W. 8th St.
WATKINS, Richard H. (J'35), Asst. to Parts Mgr., Rich-Con Hardware Co.; *for mail*, 1406 N. W. 15th St.

OKMULGEE, Mid-Continent Section

BULLEN, Clarence K. ('28; '30), Constr. Engr., Wks. Progress Admin.; *for mail,* Lucerne Apt.

PONCA CITY, Mid-Continent Section

BEST, Robt. D. (J'37), 1318 S. 5th St.
MILLER, Walter ('22), V. P., Continental Oil Co.
SIBLEY, Barrett E. (A'22), Ch. Technologist. Continental Oil Co.

SALLISAW, Mid-Continent Section

PRICE, Manuel M. (J'35).

SAND SPRINGS, Mid-Continent Section

STEVENS, Carl A. (J'24), M. E., Charge Maint. & Constr., Sinclair Refining Co.; *for mail,* 409 Garfield St.

SEMINOLE, Mid-Continent Section

NEWELL, John B. (J'35), Prod. Engr., Amerada Petroleum Corp., Box 547.

STILLWATER, Mid-Continent Section

BAKER, Ellis C. ('29), Head, M. E. Dept., Okla. A. & M. College, College Sta.
HALE, Gerald A. (J'31), Instr., Okla. A. & M. College.
LEONARD, Carroll M. (J'25), Asst. Prof. M. E., Okla. A. & M. College.
MALEEV, Vladimir L. ('21), Research Prof. M. E., Okla. A. & M. College.
THUESEN, H. G. (J'36), Assoc. Prof. Indus. Engrg., Okla. A. & M. College.
VENN, Rollo E. (J'31), Instr., Okla. A. & M. College.
YOUNG, Vincent W. ('29), Assoc. Prof. M. E., Engrg. Dept., Okla. A. & M. College.

TULSA, Mid-Continent Section

ALLEN, Hugh M. (J'35), Computer, West. Geophysical Co., Philcade Bldg., Tulsa, Okla.; *for mail,* 2307 Bakersfield, Calif.
AUERSWALD, Howard R. ('17; '25), Asst. Gen. Supt., Gypsy Div., Gulf Oil Corp., P. O. Box 661.
AYERS, Roscoe G. ('30), Div. Engr., Design, Sales & Installations, Natl. Supply Co., 504 E. Archer St.
BALLIN, Alfred E. (A'06), V. P. & Gen. Mgr., Okla. Iron Wks., 805 E. Archer St.; *for mail,* 1150 E. 24th Pl.
BARRETT, Dwight O. ('12; '26), M. E., Gulf Oil Corp., Box 661; *for mail,* 2107 N. Boston Pl.
BERNARD, Harold B. ('15; '21; '28), V. P., Sinclair-Prairie Oil Co., Sinclair Bldg.; *for mail,* 1500 S. Frisco Ave.
BOYD, Wm. Wray ('22; '35), 804 S. Knoxville.
BRINDEL, Harold F. ('25), Oper. Engr., Gasoline Dept., Gulf Oil Corp., 1st Natl. Bank Bldg.; *for mail,* 1735 S. Florence Pl.
CARPENTER, L. B., Jr. (J'36), Prod. Dept., Gypsy Div., Gulf Oil Corp.
DEAN, Rudolph R. ('36), Del Rey Prod. Co.
DUCKER, Wm. L. (J'31), Engrg. Labs., Inc., 709 Kennedy Bldg.
EATON, John Fitz (J'31), Sales, Field Engr., Jarecki Mfg. Co., 15 W. 1st St.
FINNEY, Wallace R. ('21; '28), Pres., Charge Opera., Okla. Pipe Line Co., Natl. Bank, Tulsa Bldg.
FRACK, Morris W. (J'32), Designer, Tulsa Boiler & Mchy. Co., 2020 S. Union St.; *for mail,* 1518 S. Knoxville.
GASSETT, Paul L. (J'36), 706 1st Natl. Bank Bldg.
GLASGOW, Clarence O. (J'34), Natl. Tank Co., Box 1588.
HARRIS, W. Eugene (J'33), Engr., Charge, Parts Inspc., Braden Winch Serv. Co., 1007 E. Admiral Blvd.; *for mail,* 2739 E. 5th Pl.
HELTZEL, Wm. G. ('24; '35), Gen. Supt., Stanolind Pipe Line Co., P. O. Box 591.
HOLWAY, Wm. R. ('22; '35), Cons. Engr., 302 E. 18th St.
HUTCHCRAFT, David K. ('18; '35), Sales Engr., Clark Bros. Co., 125 W. 1st St.
INGRAM, Jos. L. ('31; '35), Cons. Engr., Lubrication Dept., Barnsdall Refining Corp., Tulsa; *for mail,* 411 E. Moses St., Cushing.
JONES, J. Delbert ('27; '34; '35), M. E., Maint. Diesel Engines, Tulsa Pipe Line Div., Gulf Refining Co., Box 661.
KEMLER, Emory ('27; '33; '35), Prod. Engr., Gypsy Div., Gulf Oil Corp.
KEPLINGER, C. H. (J'32), Prod. Engr., Shell Petroleum Corp.; *for mail,* 1140 S. Gary Pl.
KERR, Arthur J. ('21; '31), Dist. Mgr., Midwest Equitable Meter Co., Box 1807.
KEYES, John H. ('30; '35), Engr., Shop Supt., Shaffer Specialty Co.; *for mail,* 628 S. Allegheny Ave.
KOTZEBUE, M. H. ('23; '25), M. E., Gasoline Plant Equip., Worthington Mch. Corp. of Okla.; *for mail,* 1526 S. Victor Ave.
LANE, R. K. ('36), Pub. Serv. Co. of Okla.
MACKINTOSH, Wm. D. (J'33), Engr., Stanolind Pipe Line Co.; *for mail,* 1116 S. Norfolk St.
MANLEY, Harold W. (J'29), Prod. Engr., Gasoline Div., Barnsdall Oil Co., P. O. Box 2033; *for mail,* 207 S. Olympia St.
McCONNELL, Glenver ('26), M. E., Charge Mid-Continent Prod. Dept., Shell Petroleum Corp., Mayo Bldg.
McGOLDRICK, J. K. (A'32), V. P., Gen. Supt., Tex. Pipe Line Co. of Okla., 706 Phitower Bldg.; *for mail,* Box 2420.
McGREGOR, John McKenzie ('28; '35), McGregor Engrg. Co., 213 Midco Bldg.
MITCHELL, Wm. D. (J'36), Jr. Engr., Prod. Engrg. Gypsy Div., Gulf Oil Corp., First Natl. Bank Bldg., 4th & Main Sts., Tulsa, Okla.; *for mail,* Ness City, Kan.
MOORE, Lee C. ('02), Retired; 319 W. 9th St.
OLSEN, Olaf LaC. (J'24), Sales Engr., Worthington Mchy. Corp. of Okla., 424 N. Boulder Ave.
ORRELL, John E. (J'34), M. E. Trainee, Shell Petroleum Corp., Mayo Bldg., Tulsa, Okla.; *for mail,* Greenwich, Kan.
PADGETT, John C. (J'36), M. E. in training, Gypsy Div., Gulf Oil Corp., Box 661, Tulsa; *for mail,* 601 E. 9th St., Claremore.
PENNEBAKER, Robt. H. ('31), Lub. Engr., Carter Oil Co., P. O. Box 801.
PORTER, Hollis P. ('10; F'36), Manager, '21-'24; Cons. Engr., P. O. Box 1241.
SCHAEFER, Henry (J'36), Engr., Stanolind Oil & Gas Co.; *for mail,* 420 S. Utica.
SHIELDS, W. H. ('31; '35), Div. Supt., Tex.-Empire Pipe Line Co., Box 2420.
SIBOLE, Barton P. ('21; '35), V. P. Charge Opera., Stanolind Pipe Line Co., Philcade Bldg.; *for mail,* 214 E. 24th Pl.
STEWART, W. Fred (J'35), Inspr., Charge All Inspc., Spartan Aircraft Co.
STIVERS, Frank A. ('22; '30), V. P. & Gen. Supt., Tex.-Empire Pipe Line Co., Box 2420.
SUTTER, L. G. ('32; '35), Engr., Mchy. Sales, Frick-Reid Supply Corp., Drawer 2481.
THOMPSON, F. Jas. ('32), 1315 S. Evanston St.
VANDERVOORT, L. A. ('19; '35), Mgr., Oil Well Accessories Co., 216 E. 3rd St.; *for mail,* 1906 W. Easton Court.
WARD, John E. (J'35), Engrg. Draftsman, Quick-Way Power Shovel Co., Denver, Colo.; *for mail,* 1410 S. Carson Ave., Tulsa, Okla.
WEIDNER, Paul G. ('12), 2733 E. 14th St.
WELLS, Cecil G. ('30; '35), Secy., Treas., Engr., Charge of Mfg., Natl. Tank Co., Sand Springs Rd.

WALTERS, Mid-Continent Section

BOWERS, Woodrow W. (J'36), Constr. Engr., Fed. Govt.; *for mail,* 414 Texas St.

OREGON

BONNEVILLE, Oregon Section

GREYSON, F. Raymond ('19; '25), Designing Engr., Columbia Constr. Co.

CORVALLIS, Oregon Section

GRAF, Saml. H. ('12; '20), Prof. M. E. & Dir. Engrg. Research, Ore. State Agri. College; *for mail,* 306 S. 8th St.
JONES, Keith (J'36), 912 S. 11th St.
MARTIN, Wallace H. ('13; '19; '28), Prof. Heat Engrg., Ore. State Agri. College; *for mail,* 327 N. 29th St.
OTHUS, J. C. ('28), Asst. Prof. M. E., Ore. State Agri. College; *for mail,* 303 N. 31st St.
PHILLIPS, Mark C. ('21), Assoc. Prof. M. E., Oregon State Agri. College; *for mail,* 529 S. 2d St.
SUMMERS, Robt. Edw. (J'25), Asst. Prof. M. E., Ore. State Agri. College; *for mail,* 2745 Arnold Way.
WILLEY, Earl C. ('23; '35), Instr. M. E., Ore. State Agri. College; *for mail,* 1652 "A" St.

ESTACADA, Oregon Section

HEDLIND, W. ('36), P. O. Box 212.

HOOD RIVER, Oregon Section

KERZEL August ('32), Engr., Charge Design, Ideal Gradery & Nursery Co., Rt. 2; *for mail,* Rt. 3.

MARSHFIELD, Oregon Section

HENDERSON, Herman B. ('30), 208 S. 10th St.

PORTLAND, Oregon Section

ARMSTRONG, Edward P. ('19), Pres., Gen. Mgr., Armstrong Mfg. Co., 2135 N. W. 21st Ave.
BASTIAN, H. S. ('24), Dist. Rep., Combustion Engrg. Co., Inc., Ry. Exch. Bldg.
BATES, Erastus N. ('17), Sr. Marketing Specialist, Charge Pacific Coast Grain and Rice Investigation, Grain Div., U. S. Dept. of Agri., 345 Federal Court House.
BERGQUAM, Norval K. (J'36), Clerk, Mech. Goods Dept., U. S. Rubber Products, Inc., 435 N. W. Glisan; *for mail,* 1326 S. W. 12th Ave.
BLOM, Carl ('36), Ch. Engr., Bingham Pump Co., 7th at Main St.
BRENNAN, Wm. Edw. (J'29), 0424 S. W. Iowa St.
BUTLER, Claude F. (J'29), 627 N. E. 21st Ave.
CALKIN, E. D. (J'33), Owner, Mgr., ELF Eng. Co., 3055 N. E. Everett St.
CLARK, A. M. ('25), Pres., Columbia Steel Casting Co., 933 N. W. Johnson St.
CORYEA, Carey E. ('36), Designing Engr., Portland Gen. Elec. Co., Elec. Bldg.; *for mail,* 2421 N. E. Irving.
DAVIS, Franklin L. ('25), Plant Engr., Northwest Ice & Cold Storage Co.; 1251 Tillamook St.
DICKSON, John ('18), M. M., Spokane, Portland & Seattle Ry. System, 39th St., Vancouver, Wash.; *home address,* 1917 N. E. Fremont, Portland, Ore.
DUNAGAN, Averitt (J'35), Engr., Vaughan Motor Co., 835 S. E. Main St.; *for mail,* 1034 S. E. Washington.
GORBUTT, S. B. ('31), Mgr., Willamette Iron & Steel Wks. Corp., 2860 N. W. Front Ave.; *for mail,* 2544 N. E. 25th Ave.
HALL, Elmon L. ('25), Oper. Mgr., Portland Gas & Coke Co., 411 Pub. Serv. Bldg.
HAYS, Lewis T. ('16; '18), Tramway Engr. & Sales, Columbia Steel Co., P. O. Box 3416.
HESLOP, Paul L. ('31), Engr., Charge Mech. Installations, U. S. Engr. Dept., War Dept., Bonneville; *for mail,* 2344 N. E. 19th Ave., Portland.
HOHL, Leonard L. ('31), Assoc. Engr. Dist. B, Region IV, Natl. Park Serv., U. S. Dept. of Interior, 712 Spalding Bldg.
HOYT, Raymond D. ('13), Pres., United Contr. Co., 311 Stock Exchange Bldg.
HUGHES, Arthur D. (J'32), Design Draftsman, Iron Fireman Mfg. Co., 4784 S. E. 17th Ave.; *for mail,* 4620 S. E. 77th Ave.
JACK, Carl Rebada ('36), Asst. M. E., U. S. Engr. Dept., 2d Portland Dist., War Dept., 637 Pittock Block.
JOOST, Geo. E. ('29; '35), Designing Engr., Willamette Hyster Co., 2902 N. E. Clackamas St.
KOLLAS, Will J. (J'31), Ch. Engr., Charge Design & Engrg., Montag Stove & Furnace Wks., 2011 N. Columbia Blvd.
LAWRENCE, Kenneth Wm. (J'36), Iron Fireman Mfg. Co., 4821 S. E. 17th St.; *for mail,* 3124 S. E. Grand Ave.
LINDROS, Ernest Edw. (J'36), Hyd. Engr., Bingham Pump Co., 705 S. E. Main St.
LISTER, Sidney M. ('30), Supt. of Properties, Sch. Dist. No. 1, Multnomah Co., 631 N. E. Clackamas St.
MATTER, Gustave O. ('20; '28), Cons. Mech. Engr., 426 Board of Trade Bldg.
McDOUGALL, G. F. ('21), Pres. & Gen. Mgr., G. F. McDougall Co., 718 Board of Trade Bldg.
McGONIGLE, Chas. ('19), Pres., Poole & McGonigle, 63d & Halsey Sts.
MEANY, Jas. M. ('17; '21), Secy., West. Loggers Mchy. Co., 302 S. W. 4th Ave.
MORDEN, Chas. Whitney ('19; '35), Pres., Morden Mchs. Co., Rm. A., Pacific Bldg.
MOY, Stanley (J'36), 1726 S. W. 2nd Ave.
MUNTZ, Peter ('35; '35), Ch. Engr. & Instr., L. L. Adcox Trade Sch., 237 N. E. Broadway; *for mail,* 3016 N. E. 11th Ave.
MYERS, Maurice Earl (J'34), F. C. Stetler Div., Fibreboard Products, Inc., 50 N. E. Oregon.
OBER, T. M. (J'34), M. E., Mech. Inspector-Supvr., Bonneville Dam, U. S. Engr. Dept., War Dept., Bonneville; *for mail,* 805 N. E. Portland Blvd., Portland.
OSIPOVICH, A. A. ('36), M. E., 2842 N. E. 14th Ave.
PELTZ, Gordon M. ('22; '35), Devel. Engr., Iron Fireman Mfg. Co., 4784 S. E. 17th Ave.
PERRY, Tom ('26), Asst. Gen. Supt., Opera. & Maint. Northwest. Elec. Co., 509 Public Service Bldg.
PERSO, Erwin E. (J'30), Lub. Engr., Tex. Co., Sta. E.; *for mail,* 3910 N. E. 99th St.
SUPOVÉ, Lawrence (J'27), Engr., Elec. Steel Fdy. Co., 2458 York St.
TAYLOR, J. Wm. (J'36), 3145 N. E. 46th Ave.
TESSITOR, Frank (J'30), Engr. Aide, Hyd. Model Testing, U. S. Engr. Dept., War Dept., 2nd Dist.; *for mail,* 1956 N. W. Everett St.
WEBBER, Harold M. ('22), Salesman, Allis-Chalmers Mfg. Co., Milwaukee, Wis.; *for mail,* 3435 N. E. 38th Ave., Portland, Ore.

REEDSPORT, Oregon Section

BOEKE, Thos. (J'30).

SHANIKO, Oregon Section

REES, John Robt. (J'35), Box 116.

THE DALLES, Oregon Section

CRAMER, Luther W. (J'32), Rodman, Chainman, U. S. Engr. Dept., War Dept., Dist. 1, Portland; *for mail,* 1525 Bluff St., The Dalles.

WARRENTON, Oregon Section

COOK, Warren G. (J'33), Cook's Garage.

WEST LINN, Oregon Section

PORTER, Arthur J. (J'33), Power Sta. Operator, Portland Gen. Elec. Co., W. Linn; *for mail*, Box 247, Oswego, Ore.

PENNSYLVANIA

ABINGTON, Philadelphia Section

EVOY, Martin ('26; '33; '35), Plant Engr., Philadelphia Wool Scouring & Carbonizing Co., Philadelphia; *for mail*, 1 Edgehill Rd., Abington.

ALIQUIPPA, Pittsburgh Section

BROWNSTEIN, Benj. ('22), Tube Mill Engr., Jones & Laughlin Steel Corp., Aliquippa; *for mail*, 517—4th St., Ellwood City.
CRONEMEYER, Henry C. ('12), Mech. Designer, Jones & Laughlin Steel Corp., Aliquippa; *for mail*, 259 College Ave., Beaver.

ALLENTOWN, Anthracite-Lehigh Valley Section

ALLEN, Philip (J'35), Jr. Exper. Engr., Internatl. Motor Co.; *for mail*, Y. M. C. A.
BECHTEL, G. Morris ('27), Draftsman, Bethlehem Steel Co., Bethlehem; *for mail*, 935 N. 7th St., Allentown.
BERNHARD, Richard (J'01), Ch. Engr., Traylor Engrg. & Mfg. Co.; *for mail*, 125 S. West St.
BUSCK, Paul G. ('35; '35), Asst. Ch. Draftsman, Lehigh Portland Cement Co.; *for mail*, 222 N. 6th St.
CULP, S. K. (J'29), Serv. Engr., Babcock & Wilcox Co., 19 Rector St., New York, N. Y.; *for mail*, 901 S. Poplar St., Allentown, Pa.
CUTTEN, Leverett H. ('23), Plant Engr., Mack-Internatl. Motor Co.; *for mail*, 724 N. 7th St.
DURHAM, J. Edw., Jr. (A'19), V. P., Bonney Forge & Tool Wks., Meadow & Tilgham Sts.
EVERETT, Harvey J. (J'35), Testing Engr., Gamble Plant, Carrier Corp., Old Emaus Rd.; *for mail*, 217 E. Walnut St.
FOSTER, Wm. I. ('23; '35), Asst. Valuation Engr., Pa. Power & Light Co., 901 Hamilton St.
FRICK, Clifford H. ('20; '35), Plant Betterment Engr., Charge Plant Improvements, Pa. Power & Light Co., 9th & Hamilton St.
FULLER, Floid M. ('07; '17; '19), Distribution Engr., Pa. Power & Light Co., 802 Hamilton St., Allentown; *for mail*, 1627 W. Market St., Bethlehem.
GISH, James A., Jr. ('14; '35), Supt., Lehigh Portland Cement Co., Sandt's Eddy, Easton; *for mail*, 136 S. 7th St., Allentown.
GREGORY, Dimitry J. ('29), 134 S. 9th St.
HOLMES, Lawrence J. ('23), V. P., Charge Mfr., Internatl. Motor Co.; *for mail*, Lanark Manor.
HUGHEY, A. H. (J'34), Rionor Ribbon Co., 381 Auburn St.; *for mail*, 503 S. 4th St.
HUTHSTEINER, Robt. Eugen ('34; '35), Sales Devel. Supvr., Indus. Sales Dept., Pa. Power & Light Co., 901 Hamilton St.; *for mail*, Americus Hotel.
JONES, Michael D. ('30), Dist. Engr., Pa. Dept. Highways, Ross Ave., Scranton; *for mail*, 120 S. 16th St., Allentown.
JOSEPHS, Lyman C., Jr. ('19; '25), Engr., Internatl. Motor Co.; *for mail*, 738 N. 26th St.
KING, Edw. Ross (J'33), Head Engrg. Dept., Utilities Serv. Co., Allentown; *for mail*, 331 Tohickon Ave., Quakertown.
LANGHAAR, Louis ('31), 427 S. 18th St.
MOYER, Robt. E., Jr. (J'29), V. P., Charge Sales, Heilman Boiler Wks., Inc., Ridge Ave. & Linden St.; *for mail*, 514 N. Lafayette.
OSWALD, E. P. (J'29), Drawing Rm. Group Leader, Internatl. Motor Co.; *for mail*, 938 Hamilton St.
PICKEL, Harry A. ('17; '35), Supt., Generation, Pa. Power & Light Co., 9th & Hamilton Sts.
PRINCE, Richard J. (J'24), Rate Auditor, Pa. Power & Light Co., 901 Hamilton St.
RABERT, Arthur P. (J'33), Lab. Asst., Testing Trojan Powder Co., 17 N. 7th St.; *for mail*, 1326 Chew St.
REINICKER, Norman G. ('13; '16; '35), V. P., Gen. Mgr., Pa. Power & Light Co., 901 Hamilton St.
STAHL, Nicholas ('18), Ch. Engr., Charge Engrg. & Constr., Pa. Power & Light Co., 901 Hamilton St.
UNGER, Louis F. (J'33), Combustion Engrg., Lehigh Portland Cement Co., Sandt's Eddy, Easton; *for mail*, 809 N. 8th St., Allentown.
WILLIAMS, David G. ('18; '24), Ch. Engr., Trojan Powder Co., 17 N. 7th St.; *for mail*, 118 S. 16th St.

ALTOONA, Central Pennsylvania Section

BLUM, Walter W. (J'31), 1108—23rd Ave.
DECKER, Harry L. (J'27), Inspr., Loco. Test Plant, Pa. R. R.; *for mail*, 111 Jaggard St.
DILLMAN, Harold F. (J'31), Draftsman, Mech. Engrs. Office, Pa. R. R.; *for mail*, 317 S. 3rd St.
GRIMSHAW, Fred'k G. ('25), Wks. Mgr., Altoona Wks., Pa. R. R.; *for mail*, 3010—3rd Ave.
KOCH, Geo. B. ('09), Gen. Foreman, Pa. R. R., S. Altoona; *for mail*, Box 566, Altoona.
PFEIFFER, Isadore F. ('26), 1103 Broadway.
REYNOLDS, Bertram A. ('31; '35), Lead Inspector, Test Dept., Pa. R. R.; *for mail*, 2421 Beale Ave.
RHOADS, Geo. E. ('06; '26), Asst. Foreman, Test Dept., Broad St. Sta. Bldg., Pa. R. R., Philadelphia, Pa.; *for mail*, 1320—20th Ave., Altoona.
SHEARER, J. Harry ('22), Pres. & Gen. Mgr., Pa. Cent. Light & Power Co., 1200—11th Ave.
SMITH, F. A. (J'32), Machinist, Juniata Shops, Pa. R. R., Altoona; *for mail*, Bellwood.
STROMEIER, Alfred H. (J'31), Mech. Engrs. Office, Pa. R. R.
YOUNG, Jas. Winfield (J'30), Gang Foreman, E. Altoona Eng. House, Pa. R. R. Co., Altoona; *for mail*, 203 Windsor St., Reading.

AMBLER, Philadelphia Section

SCOTT, Edw. C. (A'23), Buyer, Estimator, Keasbey & Mattison Co., Butler Ave.; *for mail*, 130 Tennis Ave.
TWINING, Wm. S. ('97), Willow Ave.

AMBRIDGE, Pittsburgh Section

BAUMGARTNER, Chas. G. ('13), Ch. M. E., Am. Bridge Co.
FRAME, Wm. M. ('24; '35), *Junior Award*, '27; Dir. Research, Spang Chalfant Co.
LAMONT, Neil C. ('23), Wks. Mgr., Natl. Elec. Products Corp., 338—14th St., Ambridge; *for mail*, Box 29, Sheilds.

ANDALUSIA, Philadelphia Section

FOSTER, F. Gordon (J'34).
LENNIG, Frederick, Jr. (J'33), M. E., Charge Maint., Chas. Lennig & Co., Inc., 222 W. Washington Sq., Philadelphia; *for mail*, Andalusia.

ARDMORE, Philadelphia Section

BACHMAN, Benj. B. ('14; '18), V. P., Autocar Co.
WAGNER, C. Fred 3rd (J'32), House Htg. Engr., Philadelphia Elec. Co., 5 E. Lancaster Ave., Ardmore; *for mail*, 1041 Blythe Ave., Drexel Hill.

ARNOLD, Pittsburgh Section

HARMAN, Geo. A. (J'30), Aluminum Seal Co.; *for mail*, 356 McCandless St.

ASHLAND, Anthracite-Lehigh Valley Section

LAUBENSTEIN, Albert R. ('18; '35), Gen. Mgr., Laubenstein Mfg. Co., 422 S. 3d St.

ATHENS, Anthracite-Lehigh Valley Section

CROSSLEY, Walter C. (J'27), Ingersoll-Rand Co.; *for mail*, Hotel Bonney.
JIMERSON, Francis A. ('20; '35), Ch. Engr., Ingersoll-Rand Co.

BALA-CYNWYD, Philadelphia Section

HENWOOD, Jas. B. (J'34), 306 Kent Rd.
SIBSON, Horace E. ('04; '19), V. P., Gen. Sales Mgr., Cochrane Corp., 3146 N. 17th St., Philadelphia; *for mail*, 128 Penarth Rd., Bala-Cynwyd.
WITMER, Frank P., Jr. (J'36), Assembly Line, Philco Radio & Television Corp., C. & Tioga Sts., Philadelphia; *for mail*, 26 Radcliff Rd., Bala-Cynwyd.

BEAVER, Pittsburgh Section

GRESSLY, Oscar E. ('12), Retired; 434 East End Ave.
HACKER, John W. ('30), Cons. Indus. Engr., 440 Wayne Sq.

BEAVER FALLS, Pittsburgh Section

BROWN, Jas. M. ('00; '06), Asst. Supt., Babcock & Wilcox Tube Co.; *for mail*, 4th St., Patterson Heights.
LIVINGSTONE, Edw. A. ('28), Mgr., Alloy Sales, Babcock & Wilcox Tube Co.
POWL, W. Robt. (J'33), Plant Engr., Armstrong Cork Co., College Ave.
RANSOM, Lynn H. (J'26), Engr., Keystone Driller Co., 20th St. & 8th Ave.
SADLER, Cornelius R. ('13), V. P., Babcock & Wilcox Tube Co., 47th St.
WEISS, Alex ('25; '35), M. E., Babcock & Wilcox Tube Co.; *for mail*, 3900—4th Ave.

BERWICK, Anthracite-Lehigh Valley Section

BLOOM, K. Wm. (J'27), Am. Car & Fdy. Co.
BUSH, Richard T. (J'29), Hotel Berwick.
CAMPBELL, E. D. ('16), Asst. Gen. M. E., Am. Car & Fdy. Co., 30 Church St., New York, N. Y.; *for mail*, 737 Riverview St., Berwick, Pa.
DIETRICHSON, Wm. F. ('19), Asst. M. E., Am. Car & Fdy. Co.
HERTEL, Chas. C. (J'34), Paulton Silk Corp., Washington & Sycamore Sts.
STEINMEYER, John W. ('28), Metal Engr., Am. Car & Fdy. Co.

BERWYN, Philadelphia Section

RICHARDSON, Maurice F. ('14), Gen. Mgr., M. F. Richardson & Co.

BETHLEHEM, Anthracite-Lehigh Valley Section

BENEDICT, Chas. H. ('21), 1620 Millard St.
BLAKELEY, Geo. H. ('07), V. P., Bethlehem Steel Co.
BRAY, Lennox J. ('28; '35), Gen. Foreman, Loco. Repair Shop, Bethlehem Steel Co.; *for mail*, 1920 Kenmore Ave.
BUCK, Chas. A. ('18), V. P., Charge Raw Materials, Bethlehem Steel Co., 701 E. 3d St.
BUTTERFIELD, Thos. E. ('12), Prof. of Heat, Power Engrg., Lehigh Univ.; *for mail*, 41 W. Church St.
CLEMENS, Alonzo W. ('20), Designing Engr., Constr. Engrg. Dept., Bethlehem Steel Co.; *for mail*, 322 Goepp St.
CONNELLY, John R. (J'27), Asst. Prof. M. E., Lehigh Univ.
DESCHWEINITZ, P. B. ('80), Retired Prof., Lehigh Univ.; *for mail*, 215 E. Church St.
FINE, Lewis ('20; '35), Supt., Lehigh Mech. Repair Shops, Bethlehem Steel Co.; *for mail*, 520 Lynn St.
GROFF, Jos. C. (J'24), Sales Engr., Bethlehem Steel Co., Bethlehem; *for mail*, 111 N. 4th St., Allentown.
HILPERT, Meier Geo. ('26), Asst. Engr., Charge Erection Estimating, McClintic Marshall Corp.; *for mail*, 33 W. Church St.
HOUGHTON, Horace C. (J'29), Safety Engr., Bethlehem Steel Co.; *for mail*, 826 High St.
JENNINGS, Burgess Hill ('26; '35; '35), Assoc. Prof. M. E., Packard Lab., Lehigh Univ.
KELLER, Albert T. ('14), Ch. Engr., Rm. 515, Bethlehem Steel Co.
KETCHAM, Henry H. ('28), Life Member; 8 W. Church St.
KLEIN, Arthur W. ('03; '11), Prof. M. E., Lehigh Univ.; *for mail*, 43 Wall St.
KNISELY, Edw. S. ('06), Retired; 404 Center St.
LARKIN, F. V. ('15), Dir. Mech. & Indus. Engrg., Lehigh Univ.
LAUX, J. P. ('34), Supt. Motive Power, Lehigh Valley R. R., Brighton St.; *for mail*, 1722 W. Market St.
LEHR, Chas. E. ('16), Ch. Engr., Bethlehem Steel Co.
LUCE, Alex. W. ('27; '34), Assoc. Prof., Charge Mch. Design, Lehigh Univ.
LUSK, Jas. B. (J'36), 1230 Maple St.
McCARTY, Richard J., Jr. ('21; '24), Sales Engr., Bethlehem Steel Co., Bethlehem; *for mail*, 212 N. 6th St., Allentown.
PARIS, Percy G. ('19; '19), Research Engr., Bethlehem Steel Co.
REA, Jos. T. ('28), Asst. M. M., Bethlehem Steel Co.; *for mail*, 1410 Lenox Ave.
REICHARD, Paul C. (J'24), Exper. Engr., Combustion Dept., Bethlehem Steel Co., Bethlehem; *for mail*, 1219½ Walnut St., Allentown.
RICHARDSON, Edw. A. (J'22), Spec. Engrg. (Adv. & Sales) Consultant, Bethlehem Steel Co.; *for mail*, 1102 Linden St.
SCHENCK, Chas. ('02; '16), Devel. Engr., Bethlehem Steel Co., 3rd & Buchanan Sts.
STRUBLE, Geo. W. ('17; '21), Asst. to V. P., Sales, Bethlehem Steel Co.
STUART, Milton C. ('12; '18), Prof. M. E., Lehigh Univ.
WEBSTER, Jos. F. (J'28), Draftsman, Lehigh Valley R. R., Brighton St.; *for mail*, 624 W. Union Blvd.
WEST, Arthur ('02; '18), Vice-President, '07-'09; 1st Natl. Bank.
WILLIS, Richard Lewis (J'33), Exper. Engr., Combustion Dept., Bethlehem Steel Co., E. 3rd St.; *for mail*, 75 W. Garrison St.

BIRDSBORO, Anthracite-Lehigh Valley Section

JAPIKSE, Bertrand (J'30), Engr., Charge Design, Birdsboro Steel Fdy. & Mch. Co.; *for mail*, 501 W. 3rd St.

LAUSSUCQ, H. P. L. ('21), Mgr., Hyd. Dept., Birdsboro Steel Fdy. & Mch. Co., Birdsboro; *for mail*, 6 S. Los Roble Court, Pennside, Reading.
PERSSON, Carl G. ('27; '35), Designer, Rolling Mill Dept., Birdsboro Steel Fdy. & Mch. Co., Birdsboro; *for mail*, 154 Clymer St., Reading.
PETERSON, Edw. T. ('13), Ch. Engr., Birdsboro Steel Fdy. & Mch. Co., Birdsboro; *for mail*, 538 N. 25th St., Pennside, Reading.

BLAWNOX, Pittsburgh Section

POLLOCK, W. M. (J'29), Box 73.

BLOOMSBURG, Anthracite-Lehigh Valley Section

MILLER, C. Guy (J'36), 414 Catherine St.

BLOSSBURG, Central Pennsylvania Section

NEWELL, Randall L. ('26; '34; '35), Engr., Charge Maint., Pa. Dept. of Welfare, Blossburg State Hospital; *for mail*, P. O. Box 572.

BRACKENRIDGE, Pittsburgh Section

LANGWORTHY, Wm. P. ('23), Supt., Fabrication Div., Allegheny Steel Co., Brackenridge; *for mail*, R. F. D. 2, Aspinwall.

BRADFORD, Central Pennsylvania Section

GISLER, Max ('31; '35), Refining Technologist, Kendall Refining Co.; *for mail*, P. O. Box 99.
GROW, Jos. A. ('18; '35), Ch. Draftsman, Bovaird & Seyfang Mfg. Co., 161 Main St.
LEDERER, E. R. ('20), Pres., Gen. Mgr., Bradford Oil Refining Co.
MEESE, C. R. (J'32), 319 E. Main St.
MULLHAUPT, Alfred, Jr. (J'11), Engr., Bradford Oil Refining Co.; *for mail*, 25 School St.
OCHTMAN, Leonard, Jr. ('16; '22; '29), M. E., S. R. Dresser Mfg. Co., Fisher Ave.; *for mail*, 22 Williams St.
ROSE, John H. (A'07), Pres., Bradford Oil Refining Co., 63 Main St.
STILLMAN, Raymond Bert (J'32), Machinist & Draftsman, Taylor Aircraft Co., Bradford; *for mail*, 1st St., Eldred.
WEBER, Clifford P. ('25; '35); Box 342, R. D. 2.

BRIDGEPORT, Philadelphia Section

AMBLER, F. Marple (J'35), Jr. Engr., Summerill Tubing Co., Bridgeport, Montgomery Co.; *for mail*, Rm. 310, Y. M. C. A., Norristown.
OBERHOLTZER, Robt. E. (J'31), Cost & Prod. Dept., Jas. Lees & Sons Co., Bridgeport; *for mail*, 1205 W. Oak St., Norristown.

BRIDGEVILLE, Pittsburgh Section

STRAUSS, Jerome ('36), V. P., Charge Research & Devel., Vanadium Corp. of Am.

BRISTOL, Philadelphia Section

SCHMIDT, Herman E. (J'28), Plant Engr., Rohm & Haas Co., Inc.; *for mail*, Maple Beach.
SUTTON, Wilson L. (J'34), Ch. Engr., Fleetwings, Inc.; *for mail*, Radcliffe Ave.

BRODHEAD, Anthracite-Lehigh Valley Section

FRANKS, Frederick B. ('04), V. P., Gen. Mgr., Natl. Portland Cement Co., Brodhead; *for mail*, 906 Club Ave., Allentown.

BROOKVILLE, Pittsburgh Section

JENKS, Wm. H. ('89).

BRYN MAWR, Philadelphia Section

POULTNEY, J. Livingston ('08).

BURNHAM, Central Pennsylvania Section

REPINO, Philip (J'31), M. E., Stand. Steel Wks. Co.
SMITH, John Richard (J'33), Salesman, Stand. Steel Wks. Co.

BUTLER, Pittsburgh Section

VOLD, Lars H. ('22), M. E., Designer, Stand. Steel Car Co.; *for mail*, 234 Oak St.

CARBONDALE, Anthracite-Lehigh Valley Section

HAMILTON, Wm. J. ('05), Secy., Hendrick Mfg. Co., 51 Dundaff St.
HILLER, N. H. ('02), Carbondale Mch. Co.; *for mail*, 68 Laurel St.

CARLISLE, Susquehanna Section

MASLAND, Chas. H., 2nd ('31), V. P., Charge Engrg., C. H. Masland & Sons, Inc.

CARNEGIE, Pittsburgh Section

DIGNAN, Geo. E. ('24), Gen. Supt., Charge Opera., Pittsburgh Coke & Iron Co., Neville Island, Pittsburgh; *for mail*, 27 Priscilla Lane, Rosslyn Farms, Carnegie.

CARROLLTOWN, Central Pennsylvania Section

COLEMAN, Myles B. (J'32), Mechanic, Westrick Motor Co.; *for mail*, P. O. Box 193.

CATASAUQUA, Anthracite-Lehigh Valley Section

DOUGLASS, Alfred E. ('21; '30), Pres., Fuller Co., Fuller Bldg.
GAFFNEY, Jos. B. ('27), Asst. Ch. Engr., Fuller Co.
MORROW, Jos. H. ('26; '30), Ch. Engr., Fuller Co., Fuller Bldg.
REDFIELD, Snowden B. ('10), Engr., Charge Air Compressor Design, Fuller Co., Bridge St.

CEMENTON, Anthracite-Lehigh Valley Section

HOKE, Arnold ('13), V. P., Charge Mfg., Whitehall Cement Mfg. Co.

CHADDS FORD, Philadelphia Section

WYETH, Nathaniel C. (J'36), Jr. Engr., M. E. Div., E. I. du Pont de Nemours & Co., Deepwater, N. J.; *home address*, Chadds Ford, Pa.

CHAMBERSBURG, Central Pennsylvania Section

CLARKE, Eugene C. ('21; '35), Pres., Chambersburg Engrg. Co.
DUNFORD, Gordon S. (J'30), Dist. Mechanic, Equip. Bur., Dept. of Highways, Commonwealth of Pa., Harrisburg; *for mail*, Glen Apts., Chambersburg.
HARRISON, R. E. W. ('27), V. P., Chambersburg Engrg. Co., Derbyshire St.

CHESTER, Philadelphia Section

ALEXANDER, Wm., II (J'32), Scott Paper Co., Chester; *for mail*, 908 Westdale Ave., Swarthmore.
BALLARD, Roscoe F. ('31), Dir. Research & Devel., Morgan Concentrating Corp., c/o J. H. Kennedy, 1428 Walnut St., Philadelphia; *for mail*, 37 E. Mowry St., Chester.
BOYLON, F. Oscar (J'34), 47 W. 8th St.
BUTTERWORTH, Gilbert J. (J'35), 1003 W. 7th St.
GILLIES, John H. ('35; '35), Finishing Process Engr., Scott Paper Co., Chester; *for mail*, Yorkshire Court, Drexel Hill.
SHARP, Ralph D. (J'33), 914 Meadow Lane, Buckman Village.
SHAVER, P. E. ('34), Sales Engr., Sun Shipbldg. & Drydock Co., Chester; *for mail*, 214 S. 57th St., Philadelphia.
SHILAND, Finley H. ('14; '26), Paper-Mill Engr., Scott Paper Co., Front & Market Sts.; *for mail*, 405 E. 19th St.
THOMSON, F. duP. ('92; '99), Sun Shipbldg. & Dry Dock Co., Chester, Pa.; *for mail*, 103 Delaware Road, Elkton, Md.
VOYSEY, Alfred ('20; '35), Engr., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail*, 1412 Williston St., Chester.
VOYSEY, Alfred E. (J'31), Design Draftsman, Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail*, 2425 Upland St., Chester.

CHEYNEY, Philadelphia Section

SMITHSON, Harold R. (J'34).

CHRISTIANA, Philadelphia Section

MORGENROTH, Robt. J. ('25; '34), Engr. Charge Prod., Christiana Mch. Co.; *for mail*, 414 Bridge St.

CLIFTON HEIGHTS, Philadelphia Section

KENT, Russell H. ('21; '35), Engr., Kent Mfg. Co., Clifton Heights; *for mail*, 431 Riverview Rd., Swarthmore.

COATESVILLE, Philadelphia Section

CHAPMAN, Everett ('33), Pres., Lukenweld, Inc.; *for mail*, 1130 Oak St.
CONWAY, Martin J. T. ('25), Fuel Engr., Lukens Steel Co., S. 1st Ave.; *for mail*, 99 S. 11th Ave.
HUSTON, C. L. (A'87), V. P., Lukens Steel Co.; *for mail*, 64 S. 1st Ave.
MONTORO, Alfred A. (J'34), 126 S. 3d Ave.
OLDHAM, Percy T. ('30), Mgr. Spec. Sales, Lukens Steel Co., 1st Ave.
SCHRODER, John H. (J'32), 204 Charles St.
SPACKMAN, G. Donald ('20; '23; '35), Pres., Luckenweld, Inc.

COLLINGDALE, Philadelphia Section

COMPTON, Alan Stuart (J'35), 19 Staley Ave.
SCOTT, Jack F. (J'34), 164 Wayne Ave.

COLUMBIA, Susquehanna Section

McLANE, Roye M. (J'27), 17 N. 7th St.

CONNELLSVILLE, Pittsburgh Section

PIAZZOLI, Louis P., Jr. (J'25), Ch. Engr., Capstan Glass Co.; *for mail*, 509 E. Crawford Ave.

CONSHOHOCKEN, Philadelphia Section

LOGAN, John W. ('94; '99; '04), Secy., Treas., Alan Wood Steel Co.
WILLSON, D. S. ('36), Testing Engr., John Wood Mfg. Co., Inc.; *for mail*, 329 W. 10th Ave.

COPLAY, Anthracite-Lehigh Valley Section

UHLE, David John ('28), V. P., Coplay Cement Mfg. Co., Coplay; *for mail*, 203 S. 16th St., Allentown.

CORAOPOLIS, Pittsburgh Section

CAPONECCHI, Jos. A. B. (J'34), Duquesne Steel Fdy. Co.; *for mail*, R. F. D. 2, Box 96.
PRICE, James W. (J'33), Plant Engr., Duquesne Div., Continental Roll & Steel Fdy. Co.

CORRY, Erie Section

WHITTLESEY, F. E. ('19), Gen. Mgr., Raymond Mfg. Co., 226 S. Center St.

CREIGHTON, Pittsburgh Section

RAGLAND, Richard K. (J'35), Effic. Engr., Pittsburgh Plate Glass Co.

DANVILLE, Central Pennsylvania Section

COLE, Paul W. (J'36), Engr., Kennedy-Van Saun Mfg. & Engrg. Co.; *for mail*, 221 W. Mahoning St.

DONORA, Pittsburgh Section

HOFFMAN, Chas. E. (J'36), 803 Thompson Ave.
McMAHON, John B. (J'36), Mech. Observer, Maint. Wk., Donora Steel Wks., Am. Steel & Wire Co., U. S. Steel Corp.; *for mail*, 803 Thompson Ave.
STEWART, Geo. G. ('28; '35), Head Engr., Donora Steel Wks., Am. Steel & Wire Co., U. S. Steel Corp.; *for mail*, 665 Thompson Ave.

DOWNINGTOWN, Philadelphia Section

JOHNSON, Ashmore C. (J'16), V. P., Charge Sales, Downingtown Iron Wks., Inc., Wallace Ave.
KERR, Edward ('28), V. P., Davey Co.
STANDLEY, Albert H. (J'99), V. P., Gen. Supt., Downingtown Mfg. Co., Washington Ave.; *for mail*, 336 Lancaster Ave.
STREET, Edw. T. ('29), Ch. Engr., Downingtown Mfg. Co.

DRAVOSBURG, Pittsburgh Section

PATTERSON, Peter C. ('97; '16), Retired; P. O. Box 33.

DREXEL HILL, Philadelphia Section

BUSH, Harvey W. (J'36), Jr. Engr., Shop Methods, Edw. G. Budd Mfg. Co., 25th St. & Hunting Park Ave., Philadelphia; *for mail*, 537 Harper Ave., Drexel Hill.
JONES, Frank C. (J'35), 367 Upland Way.
KUEN, Wm. E. ('15; '35), 462 Forrest Ave.
POWELL, Wm., Jr. (J'27), Sales Serv. Engr., Bailey Meter Co., 521 City Centre Bldg., Philadelphia; *for mail*, 740 Burmont Rd., Drexel Hill.

DU BOIS, Central Pennsylvania Section

OSBORN, J. R. (A'21), Pres., Gen. Mgr., Osborn Mch. Co.; *for mail*, 34 W. Scribner Ave.

DUQUESNE, Pittsburgh Section

AVERY, C. B. (J'36), Observer, Duquesne Wks., Carnegie-Ill. Steel Corp.; *for mail*, 16 S. 4th St.

EASTON, Anthracite-Lehigh Valley Section

BERNHARD, Richard L. (J'34), Engr., Ingersoll-Rand Co., Phillipsburg, N. J.; *for mail*, 77 N. 2nd St., Easton, Pa.
DEUTSCHMAN, Manuel (J'33), 1042 Washington St.
DOWSON, Harry R. ('16; '17; '27), Engr., Designing, Treadwell Engrg. Co.; *for mail*, 1801 Fairview Ave.

EATON, Paul B. ('22), Prof. M. E., Charge Dept., Lafayette College; *for mail,* 719 Cattell St.
FERNALD, Ernest M. ('18; '28), Asst. Prof. M. E., Lafayette College; *for mail,* 617 Raub St.
FORTUNE, Wm. Buckley (J'29), 518 Porter St.
HOFFMAN, Paul ('30), Ch. Engr. Charge Design, Ingersoll-Rand Co., Phillipsburg, N. J.; *home address,* Hillside Ave., Easton, Pa.
HULBERT, Wm. G. ('25), Gen. Supt., Taylor-Wharton Iron & Steel Co., P. O. Box 214; *for mail,* 121 Parker Ave.
KLEIN, Philip M. (J'35), 221 N. 14th St.
MACDOWELL, Martin H. (J'29), Engr., Condenser Engrg. Dept., Ingersoll-Rand Co., Phillipsburg, N. J.; *for mail,* 1054 Washington St., Easton, Pa.
McKELVY, Francis G. ('22), Pres., Alpha Portland Cement Co., 15 S. 3d St.; *for mail,* Oakhurst, High St.
MERRICK, Chas. M., 3rd ('26; '36), Asst. Prof., M. E. Dept., Lafayette College.
NUSIM, Melach J. ('12), Engr., Turbo-Blowers, 416 Cattell St.
POOLE, Edw. M. (J'36), Apprentice Engr., Babcock & Wilcox Co., Barberton, Ohio; *for mail,* 334 N. 11th St., Easton, Pa.
RAYMOND, Ward ('01), Pres., Gen. Mgr., Pa. Pump & Compressor Co.; *for mail,* 908 Paxinosa Ave.
REASER, W. E. (J'35), Instr. M. E. Dept., Lafayette College, 129 McCartney St.
SHELDON, Marshall B. (J'36), Student, Harvard Graduate Sch. of Business Admin., Boston, Mass.; *for mail,* 820 Porter St., Easton, Pa.
SOULIS, Wilbur T. ('25), Gen. Supt., Individual Drinking Cup Co.
VACCA, Gennaro Anthony (J'36), Jr. Engr., Metro. Edison Co., 2nd & Ferry Sts.; *for mail,* Y. M. C. A.

EAST PITTSBURGH, Pittsburgh Section

ALFSON, Chas. Wm. (J'35), Student, Sales Engrg., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.; *for mail,* 8318—10th Ave., Brooklyn, N. Y.
ARNOLD, Edwin E. ('00; '06), Cons. M. E., Westinghouse Elec. & Mfg. Co.
AUEL, Carl B. ('14), Mgr., Employees Serv. Dept., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* Orchard & 8th Sts., Irwin.
BOGAERTS, John J. ('28), M. E., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 566 Sickles St., Wilkinsburg.
DAVIS, Evan A. (J'32), Research Engr., Westinghouse Elec. & Mfg. Co.
FARR, Donald E. (J'33), Student, Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 432 Franklin Ave., Wilkinsburg.
FISCHER, Edw. G. (J'36), M. E., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* Westinghouse Club, Wilkinsburg.
HUCKA, Dale J. ('26), M. E., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 723 Cascade Rd., Pittsburgh (21).
JENNINGS, Chas. H. (J'29), Research Engr., Research Labs., Westinghouse Elec. & Mfg. Co.
KLINCK, J. H. ('04), Mgr. Office Bldgs. Opera., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 910 S. Braddock Ave., Pittsburgh (21).
KOCSIS, Julius (J'31), Draftsman, Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 125 Brown Ave., Turtle Creek.
McCLELLAND, E. S. ('91; '98), Dir. of Personnel, Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 6837 Thomas Blvd., Pittsburgh.
McVETTY, Percy G. ('20; '21), M. E., Research Labs., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 1023 La Clair Ave., Pittsburgh (18).
MIKINA, Stanley J. (J'30), *Junior Award,* '35; Research M. E., Westinghouse Elec. & Mfg. Co.
MURRAY, Arthur F. ('08; '15; '19), Wks. Mgr.'s Dept., Westinghouse Elec. & Mfg. Co.
NEWBURY, Frank D. ('29), Asst. to V. P., Westinghouse Elec. & Mfg. Co.
OSTLUND, B. T. O. ('19), M. E., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 1006 Walnut St., Edgewood, Pittsburgh.
PECK, Clarence E. ('28; '35), Engr. on Ventilation & Heat Flow Elec. Mchs., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 4064 Miller St., Wilkinsburg.
PEGG, E. H. Rebok (J'34), Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* Westinghouse Club, Pennwood Ave., Wilkinsburg.
PETERSON, Rudolph E. ('26; '29; '35), *Student Award,* '26; Mgr., Mechanics Div., Research Labs., Westinghouse Elec. & Mfg. Co.
RANKIN, Jas. Kirkpatrick (J'36), Salesman, Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 901 Hill Ave., Wilkinsburg.
ROBERTS, Philip G. ('26; '31; '35), Contact Administrator, Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 832 East Hutchinson Ave., Edgewood, Pittsburgh.
SCHAAKE, Wm. (J'98), Engr., Ry. Div., Engrg. Dept., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 304 Le Roi Rd., Pittsburgh.
STORER, Norman W. ('12), Cons. Ry. Engr., Westinghouse Elec. & Mfg. Co.
VAIDEN, John C. (J'36), Student Engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 1117 Ross Ave., Wilkinsburg.
VOLLMER, Paul L. ('21; '35), M. E., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 201 Marion Ave., Forest Hills, Wilkinsburg.
WAHL, Arthur M. ('28; '30; '35), *Junior Award,* '29; Research Engr., Westinghouse Elec. & Mfg. Co.
WEAVER, J. R. ('36), Dir. Equip., Inspc. & Test, Westinghouse Elec. & Mfg. Co., Braddock Ave.
WEBSTER, John E. ('27), Engr. of Wks., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 523 N. Negley Ave., Pittsburgh.
WELCH, W. P. (J'36), Student, Graduate Engrg. Course, Westinghouse Elec. & Mfg. Co.
WERNER, Harry C. (J'31), Research Engr., Westinghouse Elec. & Mfg. Co.
WRIGHT, Ralph H. ('29), Steel Mill Application Engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 164 Lloyd Ave., Swissvale.

EAST STROUDSBURG, Anthracite-Lehigh Valley Section

TAYLOR, Ernest H. ('22), Asst. Gen. Mgr., Internatl. Boiler Wks. Co., E. Stroudsburg; *for mail,* 500 Sarah St., Stroudsburg.

EDDYSTONE, Philadelphia Section

ANASTASI, Anthony J. (J'36), Engrg. Draftsman, Baldwin-Southwark Corp., Eddystone; *for mail,* 719 Moore St., Philadelphia.
ARMSTRONG, Edwin John ('21), Estimating Dept., Baldwin-Southwark Corp., Eddystone; *for mail,* 17 W. Main St., Lansdale.
HOWARD, Karl S. ('19), Mech. Supt., Gen. Steel Castings Corp.
McILVAINE, C. L., Jr. (J'30), Spec. Apprentice, Gen. Steel Castings Corp., Eddystone; *for mail,* 312 Bryn Mawr Ave., Bryn Mawr.
PYLE, Lewis M. ('17), M. E. Designer, Baldwin-Southwark Corp., Eddystone; *for mail,* 808 Summit Grove Ave., Bryn Mawr.
REBURN, Chas. Edw. (J'36), Calculator & Estimator, Gen. Steel Castings Corp., Eddystone, Pa.; *for mail,* 23 Ave. "C," Claymont, Del.
SCOTT, Chas. G., Jr. (J'30), Detail Engr., Baldwin Loco. Wks., Paschall Sta., Eddystone; *for mail,* 6245 Gardenia St., Germantown, Philadelphia.
SHEEHAN, Wm. M. ('20), Mgr., East. Dist. Sales, Gen. Steel Castings Corp.

ELLWOOD CITY, Youngstown Section

BAXTER, Jas. W. ('27), M. E., Natl. Tube Co.
MOORE, Frank E. (A'19), Pres. & Gen. Mgr., Mathews Conveyer Co.
STIEFEL, Ralph C. ('97), Engr., 1 Circle St.

EMPORIUM, Central Pennsylvania Section

McWHORTER, John P. (J'34), Methods Engr., Hygrade Sylvania Corp.

ERIE, Erie Section

ANDERSEN, Henry C. (J'36), Student Test Engr., Gen. Elec. Co., E. Lake Rd.
ATKINSON, Embry S. ('18; '22), V. P. in Charge, Penn Union Elec. Corp., 315 State St.
BACH, Geo. W. ('18; '19; '34), Gen. Mgr., Sales, Prod., Am. Sterilizer Co., 1230 Plum St.
BEHREND, Ernst R. ('00), Pres., Hammermill Paper Co., Eastlake Rd.
BRADT, Morris ('19; '35), Power Plant Engr., Skinner Eng. Co.
BREWER, Geo. S. ('27), Engr., Metric Metal Wks. of Am. Meter Co.; *for mail,* 1114 W. 8th St.
BUNTING, Francis W. (J'33), Engr., No. Equip. Co., 1945 Grove Dr., Erie, Pa.; *for mail,* 311 White Horse Pike, Haddon Heights, N. J.
BURKE, Jas ('16), Chmn. Bd., Burke Elec. Co.
CAIN, Basil S. ('35), Asst. Engr., Charge Design, Loco. Div., Gen. Elec. Co., E. Lake Rd.
DARLING, Kenneth M. (J'36), Student Engr., Erie Wks., Gen. Elec. Co.; *for mail,* 506 Howe Ave.
DURBAN, Thos. E. ('12), P. O. Box 385.
EMMET, Herman LeRoy ('31), Wks. Mgr., Gen. Elec. Co.
GOETZ, Harold E. ('20; '26; '35), Designing & Testing Engr., Skinner Eng. Co., W. 12th St.; *for mail,* 3927 Myrtle St.
HOLLENBECK, Gerald K. (J'29), Student Engr., Gen. Elec. Co., E. Lake Rd.; *for mail,* 233 W. 4th St.
HUNTER, Wm. L. ('23; '35), Asst. Ch. Engr., No. Equip. Co., Grove Dr.; *for mail,* Box 302.
IMS, Edw. Chas. (J'31), Motor Cost Estimator, Gen. Elec. Co., E. Lake Rd.; *for mail,* 813 Parade St.
JARECKI, Alexander ('89; '05); Pres., Jarecki Mfg. Co., 1345 W. 12th St.
JOYCE, Harry B. ('31), Cons. Engr., 810 Commerce Bldg.
KAEMMERLING, Gustav H. ('16; '22; '35), P. O. Box 67, Perry Sq. Sta.
KIRKPATRICK, F. M. (J'29), 506 Howe St., Lawrence Park.
METCALF, Geo. R., Jr. ('16; '26), V. P., Erie Malleable Iron Co.; *for mail,* 208 W. 9th St.
MITCHELL, Harold C. ('27), Supt. Maint., Power, Erie Wks., Gen. Elec. Co.; *for mail,* 917 W. 6th St.
MUELLER, Herman G. ('24), Ch. Engr., Skinner Eng. Co.; *for mail,* 649 Hilltop Rd.
OBERMANNS, Henry E. (J'30), Asst. Paper Mill Supt., Hammermill Paper Co., Hammermill Rd.
OERGEL, Chas. T. (J'29), Designing Engr., Gen. Elec. Co., Lawrence Park; *for mail,* 426 Euclid Ave.
PAYNE, Francis H. (A'17), Pres., Am. Meter Co., Inc., Box 1251.
REED, Macdonald S. ('19; '25; '30), Sales Engr., Erie Fdy. Co.; *for mail,* 402 W. 7th St.
ST. LAWRENCE, John ('17), Asst. Mgr., Gen. Elec. Co.
SCHRADER, Thos. O., Jr. ('36), Dist. Sales Agt., Erie City Iron Wks, Erie; *for mail,* 716 Investment Bldg., Pittsburgh.
SKINNER, Allan D. ('13), Pres., Skinner Eng. Co., 335 W. 12th St.
SMITH, Mark E. ('34), Ch. Engr., Union Iron Wks.; *for mail,* 227 W. 18th St.
VEENSCHOTEN, V. V. ('19; '20), Ch. Engr., No. Equip. Co., Delaware Ave. & Grove Dr.
WADSWORTH, John F. ('15; '17; '22), Cons. Engr., 818 Commerce Bldg.
WOODWARD, Arthur J. ('31), Engr., Charge Design, Loco. Div., Gen. Elec. Co., E. Lake Rd.; *for mail,* 504 Kahkwa Blvd.
YATES, Richard L. ('07; '16; '35), V. P. & Gen. Mgr., Skinner Eng. Co.; *for mail,* 1350 W. 9th St.

FOREST GROVE, Philadelphia Section

KIRK, De Nard B. (J'34), Asst. in Lab., Riegel Paper Corp.

FRANKLIN, Pittsburgh Section

ARENTZEN, Einar M. ('27; '35), Ch. Engr., Joy Mfg. Co., Buffalo St.; *for mail,* Miller Park.
CLARKE, Fred F. ('19), Engr., Joy Mfg. Co.; *for mail,* 1430 Buffalo St.
COX, Clarence E. ('29), Ch. Engr., Chicago Pneumatic Tool Co.; *for mail,* 1324 Chestnut St.
ESTERGREEN, Henry M. (J'27), Exper. Dept., Chicago Pneumatic Tool Co.; *for mail,* 850 Elk St.
HASKELL, Broderick ('03), Retired; Miller Park.
INMAN, Edw. R. ('20), Pat. Solicitor, 1122 Liberty St.
LINDSAY, Geo. L. (J'25), Ch. Draftsman, Engine Div., Chicago Pneumatic Tool Co., Orchard & Howard Sts.; *for mail,* 850 Elk St.
MILLER, Clarence A. ('16; '26; '35), Pres., Lake Erie, Franklin & Clarion R. R., Clarion; *for mail,* Franklin.
MOORE, Howard E. ('24; '31; '35), Gen. Supt., Chicago Pneumatic Tool Co.; *for mail,* Star Route.
WATERBURY, Bayard H. ('25), Supt., Eclipse Wks., Atlantic Refining Co.; *for mail,* 953 Elk St.
WILLIAMS, John Geyer (J'33), Designer, Draftsman, Diesel Dept., Chicago Pneumatic Tool Co., Howard St.; *for mail,* 1198 Otter St.

FULLERTON, Anthracite-Lehigh Valley Section

JOHNSON, J. Roland (J'28), Cadet Engr., Fuller Lehigh Co., Fullerton; *for mail,* 18 Beechwood Rd., Parkside, Chester.

GEORGE SCHOOL, Philadelphia Section

BROWN, Robert G. ('12).

GLENSIDE, Philadelphia Section

GOENTNER, Wm. B. ('05; '14), M. E., 221 W. Mt. Carmel Ave.
MITCHELL, C. O. (J'34), 109 Tyson Ave.
WOOD, Alan A. ('14; '26), Sales Engr., Builders Iron Fdy., Broad & Diamond Sts., Philadelphia; *for mail,* 104 Roslyn Ave., Glenside.

GREENSBURG, Pittsburgh Section

CROWNOVER, Jos. C. (J'36), 213 Westmoreland Ave.
McMANUS, Jos. D. ('28; '35), Asst. Ch. Engr., Charge Design, Walworth Co.
WOODCOCK, John ('16), M. E., Charge Design, Walworth Co., Huff Ave.; *for mail,* 724 Welty St.

GREENVILLE, Youngstown Section

GRAY, Guy M. ('35), Supt. M. P., Charge Design, Maint. of Shops, Locomotives & Cars, Bessemer & Lake Erie R. R. Co.
WEBSTER, Harry D. ('17), Engr., Motive Power, Bessemer & Lake Erie R. R. Co.; *for mail,* 392 S. Main St.

GROVE CITY, Youngstown Section

MITCHELL, Grover Ira ('30), 421 N. Center St.

HARRISBURG, Susquehanna Section

CASKEY, Kenneth H. (J'25), Ch. Engr., Harrisburg Steel Corp.; *for mail,* 3028 N. 2nd St.
CLAUSEN, Jens ('21), Asst. Gen. Mgr., Harrisburg Pipe & Pipe Bending Co.; *for mail,* 206 Kelso St., Paxtang.
COSDEN, Edw. D. (J'36), Air Reduction Co., 829 Paxton St., Harrisburg, Pa.; *for mail,* Southold, L. I., N. Y.
COVER, Ray W. (J'32), Tex. Co., Harrisburg; *for mail,* 1 S. 4th St., Steelton.
ECK, Alexius E. ('29), Ch. Engr., Cent. Iron & Steel Co., Harrisburg; *for mail,* 1404 Walnut St., Camp Hill.
GOLDTHWAITE, Harry W. ('13), M. E., Button Corp. of Am., 49 Dickerson St., Newark, N. J.; *for mail,* 710 N. 18th St., Harrisburg, Pa.
IRONS, Robt. H. ('22), Pres., Cent. Iron & Steel Co., S. Front St.
JASPER, Chas. A. ('35; '35), Pa. Dept. of Highways, Rm. 506, N. Office Bldg., State Capital; *for mail,* 28 N. 19th St.
LANDIS, Robt. P. (J'35), Plant Engr., Harrisburg Steel Corp., Harrisburg; *for mail,* Box 124, Dauphin.
PEARSON, Robt. ('28), Cons. Engr., 401 Mechanics Trust Bldg.
PEARSON, Wm. A. (J'33), Asst. Draftsman, Pa. Dept. of Highways, 1200 N. 3rd St.; *for mail,* 27 S. Front St.
SCHMIDT, Carl G. A., Jr. ('28), Sales Engr., 109 Boas St.

HAVERFORD, Philadelphia Section

BATTEY, Wm. A. ('19; '35), V. P., Pa. Crusher Co., Liberty Trust Bldg., Philadelphia; *for mail,* 605 Walnut Lane, Haverford.
BLACK, Edgar N., 3rd ('14; '35), Philadelphia Mgr., Fitzgibbons Boiler Co., Inc., Land Title Bldg., Philadelphia; *for mail,* 111 Woodside Rd., Haverford.
BRAY, Chas. W. ('88), Retired; Box 276.
HARRISON, John L. (J'33), "Haverford Mansions."
HETZEL, Theo. B. (J'29), Instr., Haverford College; *for mail,* 715 Panmure Rd.
HOLMES, Clayton W. ('32; '33; '35), Asst. Prof. Engrg., Haverford College.
RITTENHOUSE, Leon H. ('27), Prof. Engrg., Haverford College.

HAZLETON, Anthracite-Lehigh Valley Section

BELL, Clinton W. ('17; '35), Asst. to Supt. of Generation, Pa. Power & Light Co., Box 371.
HAENTJENS, Otto ('31), Pres., Gen. Mgr., Barrett Haentjens & Co., N. Cedar St.; *for mail,* 51 James St.
SCHILLINGER, Christian ('22), Pres. & Mgr., Coxe Stoker Sales Co., 1109 Markle Bank Bldg.
SCHMIDT, Eugene A. (J'25), Field Engr., Pa. Power & Light Co., Cedar & Buttonwood Sts.; *for mail,* Box 171.

HERSHEY, Susquehanna Section

SNAVELY, A. Bowman ('16; '21; '26), Ch. Engr., Hershey Chocolate Co.

HOLLIDAYSBURG, Central Pennsylvania Section

BOUSFIELD, Alfred ('12), Oak Knoll, R. D. 2.
KIESEL, Wm. F., Jr. ('07), Retired; 909 Penn St.

IRWIN, Pittsburgh Section

SCHEFFEL, Paul ('36), R. F. D. 1, Box 73.

JEANNETTE, Pittsburgh Section

AMOROSI, Alfred M. (J'34), Gen. Engrg. Dept., Elliott Co.; *for mail,* 108 Harrison Ave.
BARBOUR, Dana L. ('29), Engr., Charge Steam Turbine Design, Elliott Co.
KING, Marcello A. ('19; '21; '35), Mgr., Steam Turbine Dept., Elliott Co.
SMITH, John S. ('28; '34; '35), Elliott Co., Jeannette; *for mail,* 418 Ridge Way, Greensburg.

JENKINTOWN, Philadelphia Section

BASSETT, Geo. P., Jr. (J'36), Oper., Kellogg Combination Still, Atlantic Refining Co., 3144 W. Passyunk Ave., Philadelphia; *for mail,* 217 Summit Ave., Jenkintown.
KELLER, Harry H. ('30), 423 Newbold Rd.

JOHNSTOWN, Pittsburgh Section

BENNETT, Wm. H. ('18), Supt., Gautier Dept., Bethlehem Steel Co.; *for mail,* P. O. Box 533.
FRITZSCH, Theo. N. (J'31), Welding Supvr. of Design & Shop, Carnegie-Ill. Steel Co.; *for mail,* 412 Park Ave.
HUNTER, Louis N. ('36), Mgr. of Research, Natl. Radiator Corp., V. P., Charge Engrg., Natl. Air Conditioning, Inc., 221 Central Ave.
KERR, Geo. W. ('24), Combustion Engr., Bethlehem Steel Co.; *for mail,* 4 Penn Ave., R. D. 3.
LOWE, Stuart S. ('23; '25; '35), Dist. Indus. Engr., Carnegie-Ill. Steel Corp.
NEEB, Earl A. (J'34), 237 Fayette St.
RICE, Jas. R. ('24; '35), Engrg. Dept., Bethlehem Steel Co.; *for mail,* 14 Southmont Ave.

JOSEPHTOWN, Pittsburgh Section

WEATON, Geo. F. ('21), Mgr., St. Joseph Lead Co., Josephtown; *for mail,* 156 Taylor Ave., Beaver.

KINGSTON, Anthracite-Lehigh Valley Section

ROGERS, Benj. F. ('22; '24), Results Engr., Luzerne County Gas & Elec. Corp., 247 Wyoming Ave.; *for mail,* 650 Rutter Ave.
RUNTAGH, R. R. (J'34), 271 Tripp St., Swoyerville, P. O. Kingston.

LANCASTER, Susquehanna Section

BARNES, H. Gordon (J'34), Tool Engr., Bearings Co. of Am., Lancaster; *for mail,* Neffsville.
BROWN, Francis A. J. (J'26), Design Engr., Armstrong Cork Co., Lancaster; *for mail,* 127 Kready Ave., Millersville.
CRITCHLOW, Howard T., Jr. (J'36), Student, Factory Training Course, Hamilton Watch Co., Columbia Ave.; *for mail,* 632 W. Walnut St.
DECKARD, Ralph H. (J'31), Asst. Foreman in Prod., Keener Mfg. Co., 407 Lancaster Ave.; *for mail,* 249 College Ave.
DRYER, Edw. L. ('34; '35), Project Engr., Armstrong Cork Co.; *for mail,* 229 E. Frederick St.
FREY, Ralph E. (J'27), Indus. Sales Engr., Pa. Power & Light Co.; *for mail,* 127 E. Orange St.
GARDNER, Wallace Webster (J'36), Ch. Draftsman, Mch. Designer, DeWalt Products Corp., Fountain Ave.; *for mail,* Pleasure Rd., R. D. 3.
JACKSON, Henry W. ('13; '26), V. P., Charge Mfg., Bearings Co. of Am., Harrisburg Ave.; *for mail,* 154 School Lane.
JONES, Alfred ('18), Ch. Cons. Engr., Armstrong Cork Co., P. O. Box 540.
JUNGHANS, Arthur E. ('25), Cons. Engr., 726 E. King St.
KNAPP, Walter ('15; '23), Ch. Engr., Dewalt Products Corp., Fountain Ave.; *for mail,* R. 5.
LONG, David R. ('20), Pres., Tagcraft Corp., 142 S. Christian St.; *for mail,* 150 School Lane.
MAYHEW, Rodney D. (J'28), Indus. Engr., Armstrong Cork Co.; *for mail,* 231 S. West End Ave.
NOYES, Wm. ('31), Engr., Charge Design, Armstrong Cork Co., Lancaster; *for mail,* 122 Kready Ave., Millersville.
OBERG, Henry V. (J'30), Indus. Engr., Armstrong Cork Co.; *for mail,* 28 Spencer Ave.
ROBERTS, Walter (J'30), Student Engr., Armstrong Cork Co., Lancaster; *for mail,* 632 Roosevelt Blvd., Philadelphia.
ROTH, Henry ('24; '35), Mch. Designer, Hamilton Watch Co.; *for mail,* 311 Nevins St.
SMITH, Carl D. ('09; '21), Engr., Charge Furnace Design & Constr., Hocking Glass Co.; *for mail,* Rosebank.
SPENCER, Virgil (J'30), Plant Engr., Armstrong Cork Co.
STRAYER, Raymond K. (J'26), Sales Mgr., Lancaster Iron Wks., Inc.; *for mail,* 510 S. Shippen St.
THAS, Frank A. ('28), Mech. Supt., Hamilton Watch Co.
TRENOR, Fred R. (J'29), Armstrong Cork Co., Liberty & Mary Sts.; *for mail,* 912 Race Ave.
WEAVER, Wm. H. ('27; '32; '35), Indus. Engr., Floor Div., Armstrong Cork Co.; *for mail,* Susquaw Pl. & Lititz Pike, R. D. 3.
WEGMAN, Edw. Martin (J'35), Training in Foreign Opera., Armstrong Cork Co.; *for mail,* Armstrong Manor.
WICKERSHAM, John H. ('21), Owner, John H. Wickersham, Engrg. & Constr., 14 S. Duke St.

LANSDALE, Philadelphia Section

CLARKE, Phillip C. (J'26), Ch. Engr., Hunter Pressed Steel Co.
WALKER, Lee Earl ('16; '21; '35), Dist. Mgr., Charge Sales, Good Rds. Mchy. Corp., Kennett Square; *for mail,* Oak Park, Lansdale.

LANSDOWNE, Philadelphia Section

ANDERSON, Harold ('23; '30), Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 14 Nyack Ave., Lansdowne.
PEASE, Harry W. ('25), 251 Windemere Ave.
SELLS, Wm. D. (J'36), Asst. to Secy.-Treas., Robt. Morris Associates, Lansdowne Theatre Bldg.
WHITESELL, Jas. E., Jr. (J'35), 92 S. Lansdowne Ave.

LARGE, Pittsburgh Section

DUNN, Jas. Jay ('30), Large Distilling Co.

LATROBE, Pittsburgh Section

McKENNA, Roy C. ('18), Pres., Vanadium-Alloys Steel Co., 2400 Grant Bldg., Pittsburgh; *for mail,* Box 236, Latrobe.

LEBANON, Susquehanna Section

HOUSER, Jas. F. (J'31), 317 Walnut St.
KLEIN, Jos. A. (J'36), 414 N. 7th St.
LANDGRAF, Geo. F. (J'32), Y. M. C. A.
TAPPARO, John A. (J'25), Plant Supt., Steel Boiler Div., Natl. Radiator Corp., 14th & Buttonwood Sts.; *for mail,* 235 S. Lincoln Ave.

LEECHBURG, Pittsburgh Section

CONNELL, Frank G. ('22), Ch. Draftsman, W. Leechburg Steel Co.; *for mail,* R. D. 2.

LENAPE, Philadelphia Section

HANNY, Rupert M. ('36), Ch. Engr., Devel. & Application, Lenape Hyd. Pressing & Forging Co., Lenape; *for mail,* 426 Price St., W. Chester.
MOORE, Chas. H. ('31; '35), Pres., Lenape Hyd. Pressing & Forging Co., Lenape; *for mail,* 303 Chestnut St., Coatesville.

LEWISBURG, Central Pennsylvania Section

BURPEE, Frank E. ('14), Prof. M. E., Bucknell Univ.; *for mail,* 110 S. 2nd St.
KUNKEL, Geo. M. (J'21), Asst. Prof., M. E. Dept., Bucknell Univ.; *for mail,* 118 Brown St.

LEWISTOWN, Central Pennsylvania Section

FOSTER, Walter H. ('22), M. E., Stand. Steel Wks. Co., Burnham; *for mail,* 435 Valley St., Lewistown.

LIBRARY, Pittsburgh Section

ROBERTS, C. H. ('35), Asst. M. M., Natl. Wks., Carnegie-Ill. Steel Corp., Monessen; *for mail,* Library Rd., R. D. 1, Library.

LITITZ, Philadelphia Section

HANNOLD, John R. (J'28), M. E., Charge Research, Animal Trap Co. of Am.; *for mail,* Route 4.

LOCK HAVEN, Central Pennsylvania Section

HULSIZER, Robt. L. (J'21), Steam & Power Engr., N. Y. & Pa. Co., Inc., Castanea Paper Co.

MANOR, Pittsburgh Section

TRUXAL, Orin S. ('21; '35), M. E., Charge Design, Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* P. O. Box 156, Manor.

MARCUS HOOK, Philadelphia Section

ARGYLE, Wm. R. ('19; '25), Gen. Supt., Sinclair Refining Co.
CREWDSON, Henry ('19), Ch. Engr., Viscose Co.
GRISCOM, Elmer W. (J'31), Still Foreman, Sinclair Refining Co., Marcus Hook; *for mail,* 208 E. 26th St., Chester.
KUC, Anthony (J'33), Repairman, Muriatic Acid Plant, Gen. Chem. Co., Marcus Hook; *for mail,* 1014 N. Randolph St., Philadelphia.
MEURLING, Ivar ('19), Asst. Ch. Engr., Viscose Co., Marcus Hook; *for mail,* 812 Westdale Ave., Swarthmore.

McKEESPORT, Pittsburgh Section

ADAMS, Orlando P. ('22; '31), Supt. Mech. Power, Natl. Works., Natl. Tube Co.
DIFFENDAL, Jas. J. (J'34), 1002 Fawcett Ave.
JOHNSON, Leonard V. ('25; '31), Engr., Christy Park Dept., Natl. Wks., Natl. Tube Co.; *for mail,* 3007 Jenny Lind St.
JUDKINS, Malcolm F. ('32; '33; '35), Engr. in Charge, Firth-Sterling Steel Co.; *for mail,* 1810 Powers St.

MEADVILLE, Erie Section

DAVIDSON, Hobart O. ('22; '33), Ch. Engr., Charge Maint. & Design, Viscose Co.; *for mail,* 752 Chestnut St.
GROFF, Howard M. ('17; '35), 374 Byllesby Ave.
LUCHT, Fred'k W., Jr. ('15; '20; 35), Sales Engr., McCrosky Tool Corp., 1281 Main St.; *for mail* 377 Sherman St.
MILLER, Frank P. ('21), Pres., McCrosky Tool Corp.
OSGOOD, Frank G. ('28), Asst. Ch. Engr., Hookless Fastener Co.; *for mail,* 598 Pine St.
SHOEMAKER, Wm. T. (J'26), 311 Meadow St.

MECHANICSBURG, Susquehanna Section

LANDIS, Laurence H. ('21), M. E., Harrisburg State Hospital, 11th & McClay St., Harrisburg; *home address,* 430 W. Main St., Mechanicsburg.
THORNTON, W. F. ('09), R. F. D. 2.

MEDIA, Philadelphia Section

BANKS, Thos. K. ('18; '35), Asst. Engr., Crum Creek Pumping Sta., Philadelphia Suburban Water Co.

MENDENHALL, Philadelphia Section

HEFFELFINGER, H. B. (J'32), Engr., Tech. Research, E. I. du Pont de Nemours & Co., Wilmington, Del.; *home address,* Mendenhall, Pa.

MERION, Philadelphia Section

PETTINOS, Geo. F. ('13), Owner, George F. Pettinos, Inc., 1206 Locust St., Philadelphia; *for mail,* 739 Beacom Lane, Merion.
WEBRE, Alfred L. ('16), M. E.

MIDDLETOWN, Susquehanna Section

GEISINGER, Jos. M. (J'36), 212 Nisley St.
LOCKE, R. A. (A'36), Mgr., Steel Htg. Boiler Inst.; *for mail,* 500 N. Union St.

MIFFLINTOWN, Central Pennsylvania Section

ZOOK, Stanley O. (J'34), Maint. Expense Clerk, Stand. Steel Wks., Burnham; *for mail,* Mifflintown.

MILFORD, Anthracite-Lehigh Valley Section

HERBST, H. Theo. (J'33), 317 Broad St.
STROYAN, Geo. S. (J'36), Under Engr. Aide, Elec. Dept., Tenn. Valley Authority, Old P. O. Bldg., Chattanooga, Tenn.; *for mail,* Milford, Pa.

MONACA, Pittsburgh Section

BROCK, Gibson E. (J'36), Indus. Engrg. Dept., Jones & Laughlin Steel Corp., Aliquippa; *for mail,* R. D. 1, Monaca.

MONESSEN, Pittsburgh Section

JOHNS, Cyrus N. ('27), Asst. Wks. Mgr., Page Steel & Wire Co.; *for mail,* 1515 Graham Ave.
SELKIRK, W. Marshall ('17), Ch. Engr., Pittsburgh Steel Products Co., Monessen; *for mail,* 725 Broad Ave., N. Belle Vernon.

MORRISVILLE, Philadelphia Section

REID, Elmer A. ('22; '35), 67 Fairview Ave.

MT. PLEASANT, Pittsburgh Section

KOZBELT, Lloyd S. (J'34), Mullin Ave.

MOYLAN, Philadelphia Section

BARKER, Richard H. (J'29), Clerk, Personnel Dept., Sun Oil Co., Marcus Hook; *for mail,* Box 16, Moylan.

MOYLAN-ROSE VALLEY, Philadelphia Section

ATKINSON, Kenneth Biddle (J'28), 5 Rose Valley Rd.
COMLY, G. Norwood ('05; '07), V. P., New Eng. Concrete Pipe Corp., 100 Needham St., Newton Upper Falls, Mass.; *for mail,* Moylan-Rose Valley, Pa.

MUNHALL, Pittsburgh Section

CARY, Richard W. (J'34), Spec. Engr., Opera. & Maint., Homestead Wks., Carnegie-Ill. Steel Corp.; *for mail,* 609—13th Ave.
HAYS, Fred N. ('27), Asst. Spec. Engr., Carnegie-Ill. Steel Corp., Munhall; *for mail,* 119 Lincoln Ave., Edgewood, Pittsburgh.
McCONNELL, M. F. ('13), Gen. Supt., Homestead Wks., Carnegie-Ill. Steel Corp.
WARREN, Henry E., Jr. (J'34), Metal. Dept., Carnegie-Ill. Steel Corp., Homestead; *for mail* 720—10th Ave., Munhall.

MYERSTOWN, Susquehanna Section

SOLING, Sam P. (J'31), Engr., S. Liebovitz & Sons; *for mail,* 2 W. Main St.

NARBERTH, Philadelphia Section

BELL, Jas. S. ('24; '31; '35), Asst. Engine-house Foreman, Pa. R. R.; *for mail,* 208 Hampden Ave.
KUYLENSTJERNA, Adolph ('22), M. E., Am. Gas & Elec. Co., 30 Church St., New York, N. Y.; *for mail,* 232 Iona Ave., Narberth, Pa.
LAMBERT, Francis M. (J'28), 424 Grove Pl.
ROBERTS, Percival, Jr. ('88; F'36), Vice-President, '93-'95.

NAZARETH, Anthracite-Lehigh Valley Section

JONES, Edwin Hiram ('31), Boro. Engr. & Bldg. Inspr., Nazareth Boro.; *for mail,* 329 S. Broad St.
REICHENBACH, H. A. ('20), Gen. Supt., Nazareth Cement Co.

NEW CASTLE, Youngstown Section

ALLEN, John C. ('22), Asst. Gen. Supt., New Castle Wks., Carnegie-Ill. Steel Corp.; *for mail,* 301 Leasure Ave.
CARENBAUER, W. F. (J'35), 328 Shaw St.
GATES, H. G. (J'34), 302 Euclid Ave.
MADDISON, R. J. (J'34), M. E., Gen. Training Supervision, Am. Radiator Corp.; *for mail,* 212 N. Mercer St.
McAFEE, W. Keith ('23; '31), Pres., Gen. Mgr., Universal Sanitary Mfg. Co., Box 623.
ROWLAND, Roger W. ('25; '28), Pres., New Castle Refractories Co.; *for mail,* P. O. Box 193.

NEW HOPE, Pittsburgh Section

MILLER, Maj. Fred J. ('90; F'36), Manager, '04-'07; Vice-President, '07-'09; President, '20; Life Member for Distinguished Service, '22; Retired; Centre Bridge, New Hope P. O.

NEW KENSINGTON, Pittsburgh Section

FERRY, Ralph M. ('12; '21), Gen. Supt., Aluminum Co. of Am.
HARTMAN, Fred'k V. ('31), M. E., Prod. Devel., Aluminum Co. of Am.
HOAR, John C. ('14; '20), Asst. Ch. M. E., Aluminum Co. of Am., Wear-Ever Bldg., New Kensington; *for mail,* 375 Riverview Dr., Parnassus.
HOUSE, Joseph W. (J'36), 322—4th Ave.
TIEKE, Wm. ('27; '32; '35), Designing Engr., C. U. Engrg. Dept., Aluminum Co. of Am.; *for mail,* 1037 Kenneth Ave.

NEWPORT, Central Pennsylvania Section

GRING, Wilbur D. ('17; '26), Propr., Newport Hosiery Mills; *for mail,* Newport.
HOLMAN, Raymond L. (J'36), Draftsman, Pa. Dept. Highway, 2101-2103 N. 6th St., Harrisburg; *for mail,* 400 N. 4th St., Newport.

NEW WILMINGTON, Pittsburgh Section

SMYSER, E. P. (J'31), 129 Maple Ave.

NORRISTOWN, Philadelphia Section

BARKER, Geo. S. (J'16), Owner, Barker Pipe Fittings Co., 637 Markley St.
BROWNBACK, Henry L. ('21; '30), Cons. Engr., 823 W. Main St.
ORBECK, Einar M. (J'27), Sec. Engr., Charge Design, John Wood Mfg. Co., Inc., Conshohocken; *for mail,* 2100 Coles Blvd., Norristown.
OWENS, Chas. T. ('12; '20), Edgefield Farm, R. D. 2.
RIED, Robt. C. (J'34), 1013 De Kalb St.
STAFFORD, Richard G. (J'27), Appliance Serv. Supt., Schuylkill Div., Philadelphia Elec. Co., Penn & Markley Sts., Norristown; *for mail,* 149 Sumac St., Wissahickon, Philadelphia.
TUTTLE, Norman J. (J'33), Asst. Foreman, Power Dept., Continental-Diamond Fibre Co., Bridgeport, Montgomery Co.; *for mail,* 309 Haws Ave., Norristown.

NORTH HILLS, Philadelphia Section

CORBIN, Francis D. (J'33), Assembler, P. I. V. Gear Transmissions, Link-Belt Co., 2045 W. Hunting Park Ave., Philadelphia; *for mail,* 21 Fairview Ave., North Hills.

NORTH WALES, Philadelphia Section

MILLER, Wm. R., Jr. (J'34), R. F. D. 1, Box 29.

NORWOOD, Philadelphia Section

APPLEGATE, W. D. (J'34), 201 Winona Ave.
GAYER, Geo. F. (J'29), Engr., Marine Div., Westinghouse Elec. & Mfg. Co., Essington; *for mail,* 210 Leon Ave., Norwood.
TURNER, Wm. Pearson (J'36), Engr., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 130 Elmwood Ave., Norwood.

OAKMONT, Pittsburgh Section

CECIL, Robt. E. ('21), V. P., Wm. B. Scaife & Sons Co., 26 Ann St.
CLEEVES, Wm. D. (J'35), Draftsman, Erection Engr., Wm. B. Scaife & Sons Co., Ann St.; *for mail,* 317—4th St.
DUNHAM, Byron W. ('14), Ch. Engr., Edgewater Steel Co.; *for mail,* 434—9th St.
JEFFRIES, Ernest ('23; '32), Ch. Draftsman, Aluminum Co. of Am., New Kensington; *home address,* 1004—5th St., Oakmont.
SPROAT, John R. ('31), Asst. to Pres., Wm. B. Scaife & Sons Co.

OIL CITY, Erie Section

BOOTH, Howard Worthington (J'30), Engr., Charge Tests, Imperial Wks., Oil Well Supply Co.
DAUGHERTY, Samuel B. ('05), Engr., Charge Large Gas Eng. Design, Natl. Transit Pump & Mch. Co., N. Petroleum St.
DOWNS, Leslie B. ('18; '35), M. E., Natl. Transit Pump & Mch. Co.; *for mail,* 1003 W. 1st St.
FORTMANN, Edward H. ('14; '22), Gen. Mgr., Natl. Transit Pump & Mch. Co., 206 Seneca.
GNADE, Edw. R. ('95; '05), 128 Wyllis St.
HARPER, Ernest C. (J'29), Sales Engr., Ingersoll-Rand Co., 706 Chamber of Commerce Bldg., Pittsburgh; *for mail,* Box 100, S. Oil City.
KITTREDGE, B. L. ('21; '29), Ch. Draftsman, Oil Well Supply Co. of N. J.; *for mail,* 1020 W. 3rd St.
LAY, L. C. (J'29), Oper., Plant 2, Pennzoil Co.; *for mail,* 142 W. 3d St.
MATTHIESON, Harry (J'34), Prod. Engr., Oil Well Supply Co., Colbert Ave.; *for mail,* Y. M. C. A.
McCLAREN, Wm. L. (J'35), 7 Deer St.
NEWTON, Nathan A. ('14), Research Engr., Natl. Transit Pump & Mch. Co.
QUAYLE, Alex (J'36), Student Engr., Oil Well Supply Co., Colbert Ave.; *for mail,* 550 Colbert Ave.
REID, John ('23), Pres., Gen. Mgr., Jos. Reid Gas Eng. Co., Klein St.
ROGERS, Ralph W. ('14), Ch. Engr., Jos. Reid Gas Eng. Co., Main St.; *for mail,* 14 Hone Ave.

PALMERTON, Anthracite-Lehigh Valley Section

MARTIN, Raymond ('25; '31; '35), 628 Lafayette Ave.
PETERS, F. C. ('36), Ch. Engr., Charge Engrg. & Constr., N. J. Zinc Co.; *for mail,* Residence Park.
PORTER, Roy H. ('18), M. E., Charge Serv. & Maint., N. J. Zinc Co.; *for mail,* 462 Columbia Ave.

PETROLIA, Pittsburgh Section

SCHOERKE, Douglas A. ('25; '36), Ch. Engr., Charge Maint., Constr., Engrg. & Pur. Dauhgerty Refinery, Div. of L. Sonneborn Sons of N. Y.; *for mail,* P. O. Box 216.

PHILADELPHIA, Philadelphia Section

AGNER, Owen B. ('12; '19), Sales Engr., Westinghouse Elec. & Mfg. Co., 30th & Walnut Sts.
AIRSTON, Alex. J. ('21), Engr., RCA Mfg. Co., Inc., Engrg. Dept., Bldg. 5, Camden, N. J.; *for mail,* 3924 Chestnut St., Philadelphia, Pa.
ALBRECHT, Albert J. ('18; '35), Designer, Apparatus, RCA Mfg. Co., Inc., Camden, N. J.; *for mail,* 1738 N. 62nd St., Philadelphia, Pa.
ALEXANDER, Ralph M. (J'35), Design Engr., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 744—16th Ave., Prospect Park.
ALPERN, Maxwell ('16), Cons. Engr., 1203 Commercial Trust Bldg.; *for mail,* 6622 Greene St.
ALTHOUSE, Edw. G. (J'34), Asst. to Pur. Agt., Yarnell-Waring Co., 102 E. Mermaid Lane, Chestnut Hill; *for mail,* 2627 N. 27th St.
AMES, John B. (J'29), Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 221 Trites Ave., Norwood.
ANDERSON, Robt. T. ('23; '35), Engr., Charge Bldgs. & Grounds, Girard College, Sta. "C."
ANTHONY, Jas. T. ('17), V. P., Gen. Refractories Co., 1600 Real Estate Trust Bldg.
BACHMAN, Jos. L. (J'35), Jr. Engr. Aide, Naval Aircraft Factory, Navy Yard; *for mail,* 3827 Walnut St.

BACON, Howard E. ('16; '26), Spec. Rep., Stoker Dept., Westinghouse Elec. & Mfg. Co., 30th & Walnut St., Philadelphia; *for mail,* 913—10th Ave., Prospect Park.
BADENHAUSEN, John P. ('22), 620 Packard Bldg.
BAILEY, Wm. J. ('10; '17), East. Sales Mgr., Hillman Coal & Coke Co., 520 Broad St. Sta. Bldg., Philadelphia; *for mail,* 228 Essex Ave., Narberth.
BAILLIE, Robt. R. ('19; '35), Asst. Inspr., Engrg. Matl., Navy Yard; *for mail,* 115 S. 40th St.
BAILY, Robt. W. ('18), Engr., Rm. 106, Wilford Bldg., 33d & Arch Sts., Philadelphia; *for mail,* 210 Lantwyn Lane, Narberth.
BAKER, John B. ('27; '32; '35), Asst. Prof. M. E., Drexel Inst. of Tech., 32nd & Chestnut Sts.
BALTZLY, Clifford C. ('21; '30), Gen. Supt., Sta. Opera., Philadelphia Elec. Co., 1000 Chestnut St.
BANCROFT, Wilfred ('12), Treas., Lanston Monotype Mch. Co., Philadelphia; *for mail,* 761 Millbrook Lane, Haverford.
BARBA, Chas. E. ('21), Ch. Engr., Junior Motors Corp., 2545 Broad St.
BARK, Elmer ('13), Engrg. Dept., W. B. Coleman & Co., 1920 W. Indiana Ave.; *for mail,* 5014 Criscom St., Frankford.
BARNARD, John A. ('22; '35), Supt., Del. Sta., Philadelphia Elec. Co., Philadelphia; *for mail,* 1029 Blythe Ave., Drexel Hill.
BARNES, Horace B. ('22; '35), Supvr. Mech. Drafting, Philadelphia Elec. Co., 9th & Sansom St.
BARNES, Jos. M. ('21; '28), Ch. Draftsman, Philadelphia Elec. Co., 900 Sansom St.
BARRON, John T. (J'36), Sales Engr., Hynes Elec. Htg. Co., 240 Cherry St.
BARTEN, Edw. A. (J'21), Designer, 1421 E. Cheltenham Ave.
BARTH, Carl G. ('98), Life Member; Retired; 900 N. 63d St.
BARTLETT, Harry G., Jr. (J'36), Student Engr., Am. Engrg. Co., Philadelphia, Pa.; *for mail,* Walker & Sherwood Aves., Baltimore, Md.
BASSETT, Royal M. ('14; '35), Dist. Mgr., Riley Stoker Corp., 12 S. 12th St.
BATES, Arthur C. (J'36), Instr. in M. E., Univ. of Pa.
BATES, Daniel M. ('12), Pres., Bates, Inc., Packard Bldg.
BATT, Wm. L. ('11; '26), Manager, '30-'33; Vice-President, '33-'35; President, '36; Pres., SKF Industries, Inc., Front St. & Erie Ave.
BATTLE, John R. ('18; '21), Pres., J. R. Battle Co., Inc., 112 S. 16th St.
BECHTEL, John N. ('30), Salesman, Pa. Forge Corp., Milnor & Bleigh Sts.
BENDER, Eugene W., Jr. ('31; '35), M. E., Am. Mutual Liability Ins. Co., 772 Ledger Bldg.
BENNETT, John Graham (J'32), Jr. Engr., Philadelphia Gas Wks. Co., 32nd & Passyunk Ave., Philadelphia; *for mail,* 220 Sedgewood Rd., Springfield, Del. Co.
BENNETT, Jos. S., 3rd ('24; '26), M. E., Am. Engrg. Co., Aramingo Ave. & Cumberland St.
BENSON, Carl N. ('18; '26; '35), Engr. Charge Paper Mill Div., SKF Industries, Inc., Front St. & Erie Ave., Philadelphia; *for mail,* 105 Cedar St., Jenkintown.
BENZON, Geo. H., Jr. ('18), V. P., Wm. Sellers & Co, Inc., 1600 Hamilton St., Philadelphia; *for mail,* 252 Mather Rd., Jenkintown.
BERCAW, Corliss A. (J'36), Spec. Rep., Westinghouse Elec. & Mfg. Co., 3001 Walnut St., Philadelphia; *for mail,* 1000 Larchmont Ave., Penfield, Upper Darby, Pa.
BERGEY, John E. ('13), M. E., Design Sec., Navy Yard; *for mail,* 119 S. 63d St.
BESSEMER, Milton E. (J'26), Jr. Mar. Engr., Navy Yard, Philadelphia; *for mail,* 227 S. High St., Sharon Hill.
BETZ, L. Drew (A'30), Mem. Firm, Gen. Mgr., W. H. & L. D. Betz, 235 W. Wyoming Ave.
BILLINGS, J. Harland ('14; '17; '21), Prof. M. E., Drexel Inst., 32nd & Chestnut Sts.
BLAKESLEE, W. A. (J'17), Small Turbine Engrg. Dept., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* Lock Box 148, Essington.
BLATCHLEY, Chas. A. ('06), Cons. Engr., 985 Drexel Bldg.
BLUM, Sam'l. ('34), Assoc. Engr., Treas., H. M. Wilson Co., 18th & Brandywine Sts.; *for mail,* 6739 N. Smedley St.
BOCKIUS, Chas. A. ('14; '35), 120 W. Penn St.
BONINE, Chas. E. ('14), Mech. & Elec. Consultant, 1310 Land Title Bldg.
BONNER, Harry ('28; '35), Teacher, Mech. Drawing, Frankford High Sch.; *for mail,* 4634 Adams Ave., Frankford.
BORDEN, Maro M. ('13), Ch. Engr., Simplex Valve & Meter Co., 681 Upland St., Philadelphia, Pa.; *for mail,* 310 Lees Ave., Collingswood, N. J.
BORIE, Renshaw ('13; '18), Pres., A. M. Collins Mfg. Co., 226 W. Columbia Ave.; *for mail,* 1301 Spruce St.
BORTON, Geo. W. ('21), Pres., Gen. Mgr., Pa. Crusher Co., 17th Floor, Liberty Trust Bldg.
BOSBYSHELL, John H. (J'33), Engrg. Asst., Prod. Dept., Philadelphia Gas Wks., Sta. "A," 31st & Passyunk Ave.
BOSLER, Lester C. ('19), M. E., Charge Sales, Madeira, Hill & Co., 1421 Chestnut St.
BOSSINGER, E. L. ('14), Mgr., Wanamaker Garage, 23rd & Walnut Sts.; *for mail,* 551 Locust Ave., Germantown.
BOWMAN, Henry T. ('28; '35), Instr. in M. E., M. E. Dept., Univ. of Pa.
BOWMAN, Robt. A. (J'31), Design Engr., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 1102 Amosland Rd., Prospect Park.
BRACKETT, Newell, Jr. ('23; '35), Sales Engr., Brackett Co., 108 Walnut St.
BRACKIN, Richard F. (J'35), Asst. Ch. Engr., Design, Philadelphia Gear Wks., G St. & Erie Ave., Philadelphia; *for mail,* Buttonwood Ave. Andalusia.
BRAEMER, Wm. G. R. ('18), Mem. Firm, Smith & Braemer, Rm. 1265, Commercial Trust Bldg.
BRAGDON, Geo. D. ('21; '35), Mgr., Engrg., Steam Boiler & Mchy. Dept., Gen. Accident Assurance Corp., 414 Walnut St., *for mail,* 701 Marlyn Rd.
BRAUNLICH, M. W. (J'34), Inspr., Railcar Div., Edw. G. Budd Mfg. Co., 25th St. & Hunting Park Ave.
BRENDLINGER, Wm. B. (A'07), Philadelphia Branch Mgr. (Sales), Ingersoll-Rand Co., 33rd & Arch Sts.
BRENNER, Kenneth W. (J'30), Mech. Engr., Charge Design & Maint., Continental Distilling Corp., Snyder Ave. & Swanson St., Philadelphia, Pa.; *for mail,* 15 Garfield Ave., Collingswood, N. J.
BRINGHURST, G. Kendrick ('21; '27), Cons. Engr., 1700 Walnut St.
BRINLEY, Chas. E. ('13), Pres., Am. Pulley Co., 4200 Wissahickon Ave.
BRISTOL, Edw. S. ('20; '25; '35), Engr., Charge Automatic Control Div., Engrg. Dept., Leeds & Northrup Co., 4901 Stenton Ave.
BROBSTON, Jos. ('12), Exec. V. P., Hercules Cement Corp., 1700 Walnut St.
BROOKE, Geo. A., Jr. ('23), Pres. & Ch. Engr., Brooke Engrg. Co., 175 W. Huntingdon St.
BROWN, Albert M. ('15; '22; '35), Dist. Sales Mgr., Chicago Pneumatic Tool Co., 237 N. 12th St.
BROWN, Howard M. ('34), Engr. on Mech. Constr., Philadelphia Elec. Co., 9th & Sansom Sts.; *for mail,* 1449 Rosalie St.
BROWN, Jas. Paul (J'34), M. E., Designer, Smith-Drum Co., 5th & Allegheny Ave.; *for mail,* 1933 N. Newkirk St.
BROWN, Paul L. (J'35), Engr., Detail Meter Work, Simplex Valve & Meter Co., 68th & Upland Sts.; *for mail,* 128 W. Mt. Pleasant Ave.
BROWN, Richard P. ('08; '15), Pres., Brown Instrument Co., Wayne & Windrum Aves.
BROWNE, Andrew T. ('28; '34; '35), Engr., Body Div., J. G. Brill Co.
BRYANS, Henry B. ('17; '18), V. P., Charge Opera., Philadelphia Elec. Co., 1000 Chestnut St.
BRYANT, Ozro N. (J'23), Diesel Devel. Engr., Westinghouse Elec. & Mfg. Co., 30th & Walnut Sts., Philadelphia; *for mail,* 733—8th Ave., Moore.
BURMISTROFF, John G. ('24; '35), Testing Engr., Vibration Specialty Co., Harrison Bldg.; *for mail,* 1733 Spring Garden St.
BURPEE, Chandler ('21; '26; '35), Sales Engr., A. P. Short & Co.; *for mail,* 3116 W. Coulter St., East Falls P. O.
BURTON, Raymond C. ('27), Engr., Power Div., United Engrs. & Constructors, Inc., 1401 Arch St.
BYE, Norman C. ('27; '35), Ch. Engr., Henry Disston & Sons, Inc., Tacony.
CADWALLADER, Harry, Jr. ('13), Pres., Stand. Shop Equip. Co., 82nd & Tinicum Ave.; *for mail,* 1413 W. Somerset St.
CAHILL, Edw. H. ('14; '18), 11. E. Highland Ave., Chestnut Hill.
CAMP, Wm. E. (J'15), Indus. Engr., Brown Instrument Co., Philadelphia; *for mail,* 11 Edge Hill Rd., Abington.
CAMPBELL, Clarence B. ('29; '35), Asst. Div. Engr., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 553—11th Ave., Prospect Park.
CAMPBELL, Herbert F. ('29), Ch. Draftsman, Pa. Crusher Co., 1706 Liberty Trust Bldg.
CARTER, Geo. H. ('30), Asst. to Pres., Lanston Monotype Mch. Co., 24th & Locust Sts., Philadelphia, Pa.; *for mail,* 1661 Hobart St., N. W., Washington, D. C.
CAVANAUGH, Jas. P. ('22; '35), Pres., Treas., J. E. Lonergan Co., 213 Race St., Philadelphia; *for mail,* 590 Hansell Rd., Wynnewood, Narberth Sta.
CHALIKIAN, Edw. M. (J'35), Dist. Rep., Crosby Steam Gage & Valve Co., Moeller Instrument Co., Edward Valve & Mfg. Co., Witherspoon Bldg.; *for mail,* 6123 Walnut St.
CHAMBERS, Edwin G. (J'32), Time Study, J. G. Brill Co., Philadelphia; *for mail,* 64 Drexel Ave., Lansdowne.
CHARLTON, Richard C. ('16), Sales Engr., Henry Disston & Sons, Inc., Tacony; *for mail,* 4527 Primrose Rd., Torresdale.
CHASE, Philip H. ('29), Ch. Engr., Philadelphia Elec. Co., 1000 Chestnut St.
CLARK, Theobald F. ('23), Supt., Sta. A., Philadelphia Gas Wks. Co., 32nd & Passayunk Ave.; *for mail,* 490 E. Abington Ave., Chestnut Hill.
CLARKE, C. W. E. ('07; '13), Cons. Engr., 12 S. 12th St.
COBB, H. Elmore ('16; '26; '35), Engr., Bell Tel. Co. of Pa., 17th & Arch Sts., Philadelphia, Pa.; *for mail,* 21 Oakland Ave., Audubon, N. J.
COE, Frank C. ('19; '24), Registered Engr., 1261 Commercial Trust Bldg.
COLPITTS, Jas. V. ('32), Sales Engr., E. A. Kaestner Co., 516 N. Calvert St., Baltimore, Md.; *for mail,* 4821 Regent St., Philadelphia, Pa.
CONNER, Kenneth B. (J'33), M. E. Asst. to Ch. Engr., Henry Disston & Sons, Inc., Tacony; *for mail,* 1242 Marlborough St.
COOGAN, Chas. H., Jr. (J'31), Instr., M. E., Univ. of Pa.
COOK, Geo., Jr. ('24; '26; '30), Ch. Draftsman, Louis T. Klauder, 1632-4 Lincoln-Liberty Bldg.; *for mail,* 189 W. Champlost Ave.
COOK, Thos. R. ('11), Mgr. of Inspc. & Field Serv., Baldwin Loco. Wks., Paschall Sta.
COOKE, Morris Llewellyn ('03; F'36), Manager, '14-'15; Cons. Engr., Mgmt., 1520 Locust St.; *for mail,* St. Georges Rd., Mt. Airy P. O.
COOPER, John McGill, Jr. (J'34), G510 Garden Court, 47th & Pine Sts.
COPPOCK, Walter J. ('31; '32), Instr. Indus. Engrg., Ext. Div., Pa. State College; Cons. Engr., Am. Pulley Co., Philadelphia; *for mail,* Moylan-Rose Valley.
COTTA, Ralph L. ('28), Wm. Sellers & Co.; *for mail,* 1422 W. 68th Ave.
COX, John Lyman ('27), Ch. Engr., Midvale Co., Nicetown.
CROFOOT, Geo. E. ('07; '13), Prof. M. E., Univ. of Pa.
CROWLEY, Chas. L. (J'33), 4525 Higbee St.
CUSHING, Thos. E. ('28; '30; '35), Engr., Indus., Applications, SKF Industries, Inc., Front St. & Erie Ave.; *for mail,* 40 E. Walnut Lane.
DADLEY, Jas. W. ('15; '22), M. E., Penn Salt Mfg. Co., Philadelphia; *for mail,* 656 Fern St., Lansdowne.
DALLAS, John ('22), Asst. M. E., Philadelphia Elec. Co., 900 Sansom St.
DALLETT, Elijah ('00), Retired; Chestnut Hill Apt., W. Evergreen Ave.
DANIELS, Chas. W. ('32), Sales Engr., Harnischfeger Sales Corp., 587 Broad St. Station Bldg.
DAUGHERTY, Frank ('09; '25), Pres., Scofield Engrg. Co., 1324 Commercial Trust Bldg., Philadelphia; *for mail,* 160 Greenwood Ave., Jenkintown.
DAWES, Robt. ('90; '96), Retired; 1020 Dyre St., Frankford.
DEAN, Frederic H. (J'35), 802 E. Phil-Ellena St.
DeHUFF, Henry ('20), DeHuff & Hopkins, Keystone Bldg., 261 N. Broad St.
de JONY, Theo. (J'36), Training Course, Henry Disston & Sons, Inc., Tacony; *for mail,* 446 W. Mt. Airy Ave.
DELL, Ernest R. (J'33), Asst. Foreman, Gulf Refining Co.; *for mail,* 3323 N. 16th St.
DELL, William H. ('27; '33), Steam Engr., Gulf Oil Corp., Girard Point; *for mail,* 1723 Johnston St.
DELLPLAIN, Morse ('18), 261 N. Broad St.
de MAURIAC, Wm. J. (J'31), Asst. to Supt., Maint., Philadelphia Elec. Co., 27th & Christian Sts.; *for mail,* 155 W. Washington Lane, Germantown.
DIETERICHS, Frank F. (J'26), Indus. Methods & Exper. Engrg., Atlas Ball Co., SKF Industries, Inc., 4th & Glenwood Ave., Philadelphia; *for mail,* 212 Quigley Ave., Willow Grove.
DIEVERS, Grover E. ('27; '34; '35), Mech. Draftsman, Mch. Designer, Baldwin-Southwark Corp., Paschall Sta., Philadelphia; *for mail,* 1428 Powell St., Norristown.
DIMMICK, Henry S. ('23; '35; '35), Sales Rep., SKF Industries, Inc., Glenwood Ave. & American St., Philadelphia; *for mail,* 830 Homestead Rd., Beachwood, Upper Darby P. O.
Di NARDO, Harold W. (J'34), M. E., Maint., John Wanamaker, Inc.; *for mail,* 1013 N. 65th St.
DIRECTOR, Isadore (J'35), 4751 N. Franklin St.
DISSTON, Wm. D. ('16; '21; '35), 2nd V. P., Henry Disston & Sons, Inc., Tacony.
DIVAN, Louis S. (J'30), Process Engr., Baldwin Loco. Wks., Philadelphia; *for mail,* 417 Sutton Ave., Folsom.
DIXON, Chas. F. ('03; '11), Engr., Power Dept., United Engrs. & Constructors, 1401 Arch St., Philadelphia; *for mail,* Brookside Ave., Wayne.
DODGE, Kern ('02; '12), Cons. Engr., Lewis Tower Bldg., 225 S. 15th St.

DONAHUE, Paul (J'36), Draftsman, Rogers & McClain, Real Estate Trust Bldg.; *for mail*, 4606 Pulaski Ave., Germantown.
DONNELLY, Lieut. Jas. B. ('27; '33; '35), Navy Yard.
DOWELL, Dawson ('20; '22; '35), Assoc. Prof. M. E., Drexel Inst., 32nd & Chestnut St.
DOYLE, Edgar D. ('27), Pat. Engr., Leeds & Northrup Co., 4901 Stenton Ave.
DRALLE, Wm. F. (J'32), Jr. M. E., Instrument, War Plans Office, Frankford Arsenal, Philadelphia, Pa.; *for mail*, 1052 Washington Ave., Albany, N. Y.
DROBILE, Albert W. ('29), Research & Devel., Collins & Aikman Corp., 51st St., & Columbia Ave.
DUNN, Wm. R. ('10), Dir., Vulcanite Portland Cement Co., Packard Bldg., 15th & Chestnut St., Philadelphia, Pa.; *for mail*, Mt. Lakes, P. O. Denville, N. J.
EDGERTON, Lloyd B. ('13; '35), Ch. Engr. & Wks. Mgr., Philadelphia Quartz Co., 121 S. 3rd St., Philadelphia; *for mail*, 107 Chestnut Ave., Narberth.
EHLERS, Henry E. ('12), V. P., Day & Zimmermann, Inc., Packard Bldg.; *for mail*, 508 W. Mt. Airy Ave.
EIGENBROT, John L. ('21), Asst. to Pres., Gen. Coal Co., 123 S. Broad St.
EISENBREY, R. Howard ('30), Partner, Whetstone, Eisenbrey & Whetstone, 1612 Market St.
EKSERGIAN, Rupen ('21), Edw. G. Budd Mfg. Co., 25th St. & Hunting Park Ave., Philadelphia; *for mail*, 23 Owen Ave., Lansdowne.
EXLER, Donald C. (J'35), Susquehanna Elec. Co., Conowingo, Md.; *for mail*, 5141 Hazel Ave., Philadelphia, Pa.
EXLEY, Gordon R. ('36), Director, Dept. of City Transit, City of Philadelphia; *for mail*, 200 E. Cliveden St.
FASSBENDER, Walter J. (J'22), Designing Engr., Yarnall-Waring Co., 102 E. Mermaid Lane; *for mail*, 315 Nedro Ave., Olney.
FEICHT, Edw. R. ('07; '17), Supt., Power & Maint., Container Corp. of Am., Manayunk, Philadelphia; *for mail*, 111 Old Lancaster Rd., Bala-Cynwyd.
FELTON, Edgar C. ('85), Manager, '98-'01; Retired; 1581 Broad St. Sta. Bldg.
FERNALD, Robt. H. ('00; '03; F'36), Manager, '16-'19; Vice-President, '19-'21; Dean, Towne Scientific Sch., Univ. of Pa.
FERNSTROM, F. S. ('17; '31; '35), Charge Spec. Serv., Ernst & Ernst, Fidelity-Philadelphia Trust Bldg.; *for mail*, 5515 Wissahickon Ave.
FIELD, Fred'k C. ('16), 3021 W. Coulter St.
FINE, Bernard M. ('14; '19; '35), Midvale Co., Nicetown; *for mail*, Roslyn Hall, 17th & Roslyn Sts., & Limekiln Pike.
FISCHER, Ad. Korting ('04), Pres., Schutte & Koerting Co., 12th & Thompson St.; *for mail*, 6904 Wissahickon Ave.
FISHER, G. Kenneth (J'36), Asst. Engr., Cochrane Corp., 17th St., below Allegheny Ave.; *for mail*, 7235 Ogontz Ave.
FITZGERALD, J. Morgan ('27), 354 Berkley St.
FLANDERS, W. B. ('15), Mar. Engr., Westinghouse Elec. & Mfg. Co., Lester Branch P. O.; *for mail*, 6043 Ellsworth St.
FLETCHER, N. R. ('24; '30; '35), Sales Engr., Diesel Eng. Dept., Baldwin-Southwark Corp., Paschall P. O., Philadelphia; *for mail*, 319 Urban Ave., Norwood.
FOGG, Wm. R. ('21), Member & Secy., Ballinger Co., 105 S. 12th St., Philadelphia; *for mail*, 41 W. Stratford Ave., Lansdowne.
FORESMAN, Robt. A. ('19), Ch. Engr., Stoker Dept., Westinghouse Elec. & Mfg. Co., 3001 Walnut St.
FORSCHNER, Alfred J. ('21; '25), Pres. & Treas., Atlas Conveyor Co., Inc., Philadelphia; *for mail*, 605 Mason Ave., Drexel Hill.
FOX, Winters B. ('21; '26; '35), Asst. Supt., Delta File Wks., 4837 James St.; *for mail*, 3243 Stanwood St.
FRANK, Arnold S. ('26; '29; '35), Pump Engr., Westinghouse Elec. & Mfg. Co., Lester Branch P. O.; *for mail*, 1409 S. 51st St.
FREEDLEY, Paul ('20), St. James Hotel, 13th & Walnut Sts.
FRY, Horace P. ('20), Prof. M. E., Univ. of Pa.
FULLER, Walter D. (A'13), Pres., Curtis Publ. Co., Independence Sq.
FULLERTON, H. P. (J'33), Sales Dept., Estimating & Negotiating, Am. Engrg. Co., Aramingo & Cumberland Sts.; *for mail*, 401 E. Sharpnack St.
FULWEILER, John E. ('08; '13), The Madison, 22nd & Walnut Sts.
FUNK, Nevin E. ('18), V. P., Charge Engrg., Philadelphia Elec. Co., 1000 Chestnut St.
FURMAN, Jay (J'34), Engr., Charge Prod., Steelcraft Venetian Blind Co., 811 N. 19th St.
GALLOWAY, Chas. D. ('13), Asst. Factory Engr., Elec. Storage Battery Co., 19th St. & Allegheny Ave.
GALSON, Henry L. (J'26), Prod. & Devel. Engr., Charge Air Conditioning, Baldwin-Southwark Corp., Paschall P. O., Philadelphia; *for mail*, 228 Benjamin West Ave., Swarthmore.
GARRETT, Robt. E. (A'20), Div. Mgr., Gulf Oil Corp., 1515 Locust St.
GENTZEL, Perry H. ('14; '35), Ch. Engr., J. E. Lonergan Co., 213 Race St.
GESS, Louis ('28; '36), Flow Meter Engr., Brown Instr. Co., Wayne & Roberts Aves.
GILMAN, Franklin W. ('13; '15; '20), Plant Engr., Atwater Kent Mfg. Co., 4700 Wissahickon Ave.
GITTELMAN, Arthur B. (J'33), Test Engr., Philadelphia Storage Battery Co.; *for mail*, 3734 N. 18th St.
GLASBY, John B. ('36), Power & Test Engr., Atlantic Refining Co., 260 S. Broad St.; *for mail*, 2025 Griffith St.
GLENN, Edw. R. ('16; AM'18), Charge Engrg., S. L. Allen & Co., Inc., 5th & Glenwood Ave.; *for mail*, 1438 N. 13th St.
GLENN, Graeff W. (J'35), Sales Engr., Cities Service Co., 400 N. Broad St.; *for mail*, 7800 York Rd., Elkins Park.
GLUECK, Frank J. ('30), Constr. Engr., 1258 Commercial Trust Bldg.; *for mail*, 4942 N. Warnock St.
GODFREY, Ralph ('24; '30; '35), Asst. M. E., Indus. Dept., Navy Yard, Philadelphia; *for mail*, Shirley Court "E," Long Lane, Upper Darby.
GOEHRING, Walter Wm. (J'34), Draftsman, Bearing Design Div., SKF Industries, Inc., Front St. & Erie Ave.; *for mail*, 1927 Middleton St.
GOETZ, Victor J. ('93; '15), 5128 N. Carlisle St.
GOETZENBERGER, Ralph L. ('16; '20; '29), V. P., Charge Market Devel. & Research, Brown Instrument Co., Wayne & Roberts Aves.
GOLDSMITH, Lester M. ('17; '21; '35), Mgr., Gen. Engrg. & Constr. Dept., Cons. Engr., Atlantic Refining Co., V. P., Charge Engrg., Atlantic Pipe Line Co., Cons. Engr., Keystone Pipe Line Co., 260 S. Broad St.; *for mail*, 1012 W. Upsal St., Germantown.
GOODWIN, Harold, Jr. ('24), Cons. Engr., Rm. 601, 133 S. 12th St., Philadelphia; *for mail*, Wyncote.
GOODWIN, Richep M. (J'32), Test Engr., Atlantic Refining Co., 3144 Passyunk Ave.; *for mail*, 4806 Springfield Ave.
GORDON, Walter S., Jr. (J'30), Supt. Elec. Constr., Navy Yard, Bldg. 1, League Island, Philadelphia; *for mail*, 606 Millbank Rd., Upper Darby.
GOTWALS, Chas. S. ('20; '26), Prod. & Planning Mgr., SKF Industries, Inc., Front St. & Erie Ave., Philadelphia; *for mail*, 107 Cypress Ave., Jenkintown.
GRAF, John C. ('13; '18; '35), Sales Engr., Baldwin-Southwark Corp., Paschall P. O.; *for mail*, 705 E. Longshore St.
GRANDINETTI, John R. (J'30), M. E., Design, Navy Yard; *for mail*, 5634 N. 19th St.
GRANFELT, Ernest H. (J'35), Designer, Charge Limitorque Div. Engrg., Philadelphia Gear Wks.; *for mail*, 728 E. Haines St., Germantown.
GRIBBEL, W. Griffin ('27), V. P., Am. Meter Co.; Fidelity-Philadelphia Bldg.
GROOTHUIS, Herman ('22), Engr., United Engrs. & Constructors, Inc., 112 N. Broad St., Philadelphia; *for mail*, 7523 W. Chester Pike, Upper Darby.
GROSS, Samuel ('23; '35), Treas., Sheffler-Gross Co., Inc., 203-11 Drexel Bldg.
GROW, Oliver W. (J'32), Atlantic Refining Co.; *for mail*, 535 E. Gates St., Roxborough.
GUERNSEY, Chas. O. ('30), V. P., J. G. Brill Co., 62nd & Woodland Ave.
GULICK, Lee Nelson ('23; '35), Prof. M. E., Univ. of Pa., 33rd & Locust Sts., W. Philadelphia.
GUTHRIE, John F. ('17; '21; '35), Factory Mgr., Abrasive Co., Tacony & Fraley Sts.; *for mail*, 212 W. Highland Ave.
HACKETT, H. Berkeley ('24), Cons. Engr., Archs. Bldg., 17th St. at Sansom.
HAINES, Edw. P. ('07), 110 E. Durham St., Mt. Airy.
HALL, Peter P.-G. ('27), Pres., Hall Planetary Co., Fox St. & Abbotsford Ave.
HANGER, S. Ryland ('30; '35), Asst. Supvr., Customer Tests, Philadelphia Elec. Co., 2301 Market St.
HARLOW, Jas. H. ('25; '35), Asst. Supt., Sta. Economy Sect., Philadelphia Elec. Co., 1000 Chestnut St.
HARMAN, William H. (A'06), Pres., Southwark Fdy. & Mchy. Co., 400 Washington Ave.
HARMER, John G. ('27; '35), Plant Supt., Atlantic Elev. Co., D St. & Erie Ave.
HARRIS, Harold C. (J'32), 226 Zeralda St.
HARRIS, Henry S. ('18), Pub. Relations, Franklin Inst., 20th & Pkwy., Philadelphia; *for mail*, 4 Greenwood Pl., Wyncote.
HARRISON, Harry ('13; '19), Carrier Corp., 12 S. 12th St., Philadelphia; *for mail*, 801 Stanbridge Rd., Drexel Hill.
HARVEY, Cyrus R. (J'32), Inspc. Dept., S. L. Allen Co., 5th & Glenwood Ave., Philadelphia; *for mail*, 25 E. 4th St., Media.
HAUG, John S. ('27), Cons. Gas Engr., United Engrs. & Constructors, Inc., 1401 Arch St.
HEISER, Geo. H. (J'36), Jr. Engr., Turbine Div., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail*, 4027 Lasher Rd., Drexel Hill.
HEMENWAY, S. H. ('23; '35), Design Engr., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail*, 314 N. Chester Rd., Swarthmore.
HEPKE, Wm. C. ('30), Ch. Engr., Thos. M. Royal & Co., 5800 N. 7th St.
HERR, Wm. A. ('22; '28), Engr., Philadelphia Elec. Co., 1000 Chestnut St., Philadelphia; *for mail*, 122 Tyson Ave., Glenside.
HERSEY, Mayo D. ('12; '14; '19), Research Assoc. in Engrg., Div. of Engrg., Brown Univ., Providence, R. I.; *for mail*, Kingsbury Mch. Wks., Inc., 4320 Tackawanna St., Philadelphia, Pa.
HERWEGH, Lorenz J. ('31), Engr., Charge Design, Pa. Museum of Art, 25th & Parkway; *for mail*, 6021 Clifford Terrace.
HICKMAN, Charles D. ('14), Cons. Engr., Otis Bldg.; *for mail*, 2416 Bryn Mawr Ave.
HILL, Chas. H. (A'07), Asst. Designing Engr., Gen. Elec. Co., 6901 Elmwood Ave., Philadelphia; *for mail*, 628 Foss Ave., Drexel Hill.
HIRES, J. Edgar ('22; '26), Pres., Hires, Castner & Harris, Inc., 2025 Fidelity-Philadelphia Trust Bldg., Philadelphia; *for mail*, 107 Linwood Ave., Ardmore.
HOFFER, Howard A. ('18; '24; '27), East. Sales Mgr., U. S. Pipe & Fdy. Co., 1624-30 Lincoln-Liberty Bldg.
HOFFMAN, David (J'31), Radio Worker, Philadelphia Storage Battery Co., Tioga & C Sts.; *for mail*, P. O. Box 606.
HOMAN, Wm. W. (J'30), Engrg. Asst., Kingsbury Mch. Wks., Inc., 4324 Tackawanna St.; *for mail*, 1647 Allengrove St., Frankford.
HOOPES, Penrose R. ('20; '26), 37 S. 13th St.; *for mail*, 131 W. Mt. Airy Ave., Germantown.
HOPPING, Ernest L. ('19), M. E., Philadelphia Elec. Co., 900 Sansom St.
HORTON, R. Harland ('22), Exec. Dir., Philadelphia Business Progress Assn., 1442 Widener Bldg., Philadelphia; *for mail*, Russell Rd., Paoli.
HOUGHTON, C. A. ('35; '35), Day & Zimmerman Engrg. & Constr. Co., Inc., Philadelphia, Pa.; *for mail*, 55 Cleveland Terrace, E. Orange, N. J.
HOUSTON, Geo. H. ('13), Pres., Baldwin Loco. Wks., 123 S. Broad St.
HOWARTH, H. A. S. ('08), *Worcester Reed Warner Medallist, '36*; V. P., Gen. Mgr., Kingsbury Mch. Wks., Inc., 4324 Tackawanna St.
HOWELL, Wm. R. (J'28), Time Study Engr., SKF Industries, Inc., Front St. & Erie Ave.; *for mail*, 8119 Eastern Ave., Chestnut Hill.
HOYT, Wm. R. ('29), Wks. Mgr., Philadelphia Div., Yale & Towne Mfg. Co., 4530 Tacony St., Philadelphia; *for mail*, 114 Glenn Rd., Jenkintown.
HUBER, Geo. L. ('30; '35), Constr. Supt., W. K. Mitchell & Co., Inc., 2940 Ellsworth St.
HUNT, Jas. E. ('21; '35), Plant Supt., Philadelphia Elec. Co., Delaware Ave. & Lewis St., Philadelphia; *for mail*, 106 Pennsylvania Ave., Brookline, Upper Darby.
HUNTER, Chas. W. ('11; '12), V. P., Charge Gas Plant Constr., United Engrs. & Constructors, Inc., 1401 Arch St.
HUTTINGER, Wm. R. (J'06), V. P., Engrg. & Plant Mgr., Elec. Power Equip. Corp., 412 N. 18th St., Philadelphia; *for mail*, 86 E. Greenwood Ave., Lansdowne.
HYNES, Lee P. ('29), Pres., Ch. Engr., Hynes Elec. Htg. Co., 240 Cherry St.
IDDLES, Alfred ('13; '17; '22; F'36), Manager, '34-'37; Exec. V. P., United Engrs. & Constructors, Inc., 1401 Arch St.
IRMER, Chas. B. ('19; '25; '35), M. E., Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia; *for mail*, P. O. Box 884, Roslyn.
IRWIN, Kilshaw M. ('17; '23; '30), Asst. to V. P., Charge Engrg., Philadelphia Elec. Co., 1000 Chestnut St.
JANSSON, Oscar E. (J'35), Maint. & Pur., Erik Jansson, Inc., 913 E. Girard Ave.
JENSEN, Jas. A. ('18; '23; '35), Secy., Charge Engrg., Quaker City Iron Wks., Aramingo Ave. & Ontario St.; *for mail*, 3840 Lancaster Ave.
JETTER, Wm. ('22), Sales Engr., SKF Industries, Inc., Front St. & Erie Ave., Philadelphia, Pa.; *for mail*, 827 Clinton Pl., River Forest, Ill.
JOHNSON, Theo. Woolsey, Jr. (J'30), Asst. M. E., Tool Engr., Naval Aircraft Factory, Navy Yard, Philadelphia; *for mail*, 83 S. Lansdowne Ave., Lansdowne.
JONES, Chas. C. ('26), Asst. Supt., Constr. & Maint., Philadelphia Gas Wks. Co., 1800 N. 9th St.; *for mail*, 226 E. Highland Ave.
JORGENSEN, Paul Edward (J'31), Engrg. Aide, Asst. to Engrs., Naval Boiler Lab., Navy Yard; *for mail*, 1310 N. Alden St.
JURAM, Wm. C., Jr. (J'34), Sales Engr., Bristol Co., 220 E. 42nd St., New York, N. Y.; *home address*, 2476—79th Ave., Philadelphia, Pa.

KABAKJIAN, Edmund J. (J'29), Matl. Control Engr., RCA Mfg. Co., Inc., Camden, N. J.; *for mail,* 317 S. 60th St., Philadelphia, Pa.
KAUFFMAN, Sam. H. (J'36), Engrg. Dept., Downingtown Iron Wks., Downingtown; *home address,* 1239 Stiles St., Philadelphia.
KAUFMAN, Albert R. (J'33), 8210 High School Rd., Elkins Park.
KAVANAUGH, Wm. H. ('02; '10), Prof. M. E. Dept., Univ. of Pa.
KEENE, Burton F. ('29; '35), Sales Engr., Leeds & Northrup Co., 4901 Stenton Ave.
KELLY, T. Edison (J'28), Indus. Engr., Atlantic Refining Co., Point Breeze; *for mail,* 5015 Copley Rd., Germantown.
KENNEY, Lewis H. ('04; '11), Prin. Mar. Engr., Indus. Dept., Navy Yard.
KENT, S. Leonard, Jr. ('27), Engr. & Treas., Philadelphia Hydro Elec. Co., Manayunk, Philadelphia; *for mail,* 630 Winsford Rd., Bryn Mawr.
KERR, Robt. L., Jr. (J'29), Spec. Engr., Power Plant, Atlantic Refining Co., 3144 Passyunk Ave., Philadelphia; *for mail,* 215 Leon Ave., Norwood.
KERR, S. Logan ('21; '26; '34), *Junior Award,* '21; 30 E. Mt. Pleasant Ave.
KESSLER, Herbert H. ('15; '20; '27), Engr., Crushing & Cement & Min. Mchy. Div., Allis-Chalmers Mfg. Co., Broad St. Sta. Bldg., Philadelphia; *for mail,* 605 Cloverly Ave., Jenkintown.
KESSLER, John Rissel ('23; '35), Oak Lane Tower Apts.
KHRENNIKOFF, Geo. V. (J'32), Design Engrg., Westinghouse Elec. & Mfg. Co., Lester Branch P. O.; *for mail,* 4807 Chester Ave.
KIEHL, Eugene P. ('17; '24), Air Conditioning, 2204 Chestnut St.
KINGSBURY, Albert ('92), *A. S. M. E. Medallist,* '31; Pres., Kingsbury Mch. Wks., Inc., 4324 Tackawanna St., Frankford.
KIRKPATRICK, Alton ('18; '22), Cons. Engr., Wood & Kirkpatrick, Stock Exchange Bldg., Philadelphia; *for mail,* 192 N. Lansdowne Ave., Lansdowne.
KITE, Henry J. ('15; '23), Asst. Supvg. Engr., Strawbridge & Clothier, 8th & Market Sts., Philadelphia; *for mail,* 20 Lodges Lane, Cynwyd.
KLAUDER, Louis T. ('16), Cons. Engr., 1632 Lincoln-Liberty Bldg.
KLUMPP, John B. ('09), Cons. Engr., 123 S. Broad St.
KNIGHT, Seymour H. ('19), Supvg. Engr., Constr., Maint. & Mech. Opera., Strawbridge & Clothier, 8th & Market Sts., Philadelphia; *for mail,* 615 Manoa Rd., Penfield, Upper Darby.
KNIPE, Robt. K. (J'33), Jr. Engr., Navy Engr. Dept., E. G. Budd Mfg. Co., 25th St. & Hunting Park Ave.; *for mail,* 6629 N. 8th St.
KOCH, Chas. (J'16), 6203 Cobbs Creek Pkwy.
KOHUT, Frank J. ('34), Spec. Rep., Sales Engr., Ingersoll-Rand Co., Philadelphia, Pa.; *for mail,* P. O. Box 753, Wilmington, Del.
KOONS, G. I. (J'29), Cons. Engr., Hires, Castner & Harris, Inc., 2518 Morris St.; *for mail,* 5224 N. 10th St.
KOPLIN, Robt. D. ('11; '21; '35), Power Designer, United Engrs. & Constructors, Inc., 1401 Arch St.; *for mail,* 6367 Montour St.
KOTHNY, G. L. ('05; '12), V. P., Gen. Mgr., Sperry-Sun Well Surveying Co., 1608 Walnut St.
KROON, R. P. (J'32), Research Engr., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 420 Park Ave., Swarthmore.
KUBA, Geo. (J'35), 3507 Baring St.
KULJIAN, Harry A. ('21; '24; '27), Cons. Engr., Philadelphia; *for mail,* 207 Dupont St., Ridley Park.
LAFORE, J. A. ('04), V. P., Gen. Mgr., Lang Co., 848 Land Title Bldg., Philadelphia; *for mail,* Box 297, Penn Valley Farm, Narberth.
LAHENS, Chas. E. B. (J'30), Engr., Welsbach St. Illum. Co., 261 N. Broad St.
LAKEY, Arthur B. ('13; '35), Gen. Engr., Kingsbury Mch. Wks. Inc., 4320 Tackawanna St.
LAMBORN, J. Paul ('19; '27), Salesman, Domestic Appliances, Philadelphia Gas Wks. Co., 5230 Chestnut St.; *for mail,* 1661 N. Felton St.
LARNER, Chester W. ('07; '12), Pres., Larner Engrg. Co., Lincoln-Liberty Bldg.
LAUER, Conrad N. ('03; '23; F'36), Manager, '26-'29; Vice-President, '29-'31; President, '32; Pres., Philadelphia Gas Wks. Co., 1401 Arch St.
LAUGHTON, Watson B. (A'36), Supt. Press Rooms, Cuneo East. Press, Erie Ave. & G St.; *for mail,* 6024 Webster St.
LAWRENCE, H. F. ('08; '22), Am. Engrg. Co.
LEE, Geo. F., III (J'35), Law Student, Univ. of Pa.; *for mail,* "Fairfax," 43d & Locust Sts.
LEE, Robt. Jas. (J'34), Engr., Edw. G. Budd Mfg Co., 25th St. & Hunting Park Ave.; *for mail,* 2356–77th Ave.
LEIPPER, Alex. D. ('23; '30), Designing Engr., Brown Instrument Co.; *for mail,* 4639 Greene St.
LEVINSON, Herman J. ('29), Cons. M. E., 4929 N. Warnock St.
LEVY, Lionel F. ('22; '35), Partner, Tech. Div., Max Levy & Co., Wayne Ave. & Berkley St.
LINCH, E. P. ('02), 2126 Nicholas St.
LITTLE, Jos. W. (J'35), Sales, Firth-Sterling Steel Co., 1121 Frankford Ave., Philadelphia; *for mail,* 5 Hampton Terrace, Bala.
LIVERSIDGE, Horace P. ('17), Manager, '21-'24; V. P., Gen. Mgr., Philadelphia Elec. Co., 1000 Chestnut St.
LONGENECKER, Charles ('92), Commercial Trust Bldg.
LORE, Robt. T., Jr. (J'36), Engr., Asst. in Research Dept., Proctor & Schwartz Co., 7th St. & Tabor Rd., Philadelphia, Pa.; *for mail,* 19 Harvard Ave., Collingswood, N. J.
LOSS, Henrik von Z. ('92), Retired; University Club, 16th & Locust Sts.
LOUGHERY, Wm. E. (J'30), Supvr., Philadelphia Storage Battery Co., "C" & Ontario Sts.; *for mail,* 46 W. Wyneva St., Germantown.
LOVEKIN, Raymond E. (A'27), Pres., R. E. Lovekin Corp., 34 S. 17th St., Philadelphia; *for mail,* 415 Tasker St., Ridley Park.
LOVELL, Alfred ('99), Cons. Engr., 619 Harrison Bldg.
LYFORD, Frederic E. ('36), Asst. to V. P., Dir. Sales, Baldwin Loco. Wks.
LYNCH, Edw. A. ('28; '35), Edw. A. Lynch Machy. Co., N. E. Cor. 36th & Walnut Sts.
MacDONALD, Jas., Jr. (J'30), Foreman, Relay Assembly, Gen. Elec. Co., 6901 Elmwood Ave., Philadelphia; *for mail,* 119 W. 17th St., Media.
MACHOLD, Chas. E. ('01), Hillcrest Ave., Chestnut Hill.
MACKENZIE, W. P. ('07), Assoc. Engr., Bd. Dirs., Mackenzie Engrg. Co., 609 Spring Garden St.
MacLAREN, Thos. F. (J'31), Sales Engr., Brown & Sharpe Mfg. Co., Providence, R. I.; *for mail,* 14th Fl., Inquirer Bldg., Philadelphia, Pa.
MANNING, Wm. T. ('35), Engr., Charge Design, Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 407 Cresswell St., Ridley Park.
MANZ, Louis C. ('13), Cons. Engr., 503 Real Estate Trust Bldg.
MARKEY, Harold I. ('14; '20; '35), East. Dist. Mgr., Diamond Chain & Mfg. Co., Indianapolis, Ind.; *for mail,* 1011 Chestnut St., Philadelphia, Pa.
MARKLAND, Geo. L., Jr. ('22), Chmn. Bd., Philadelphia Gear Wks., G St. & Erie Ave.
MAULE, Alfred C. (A'22), Dist. Sales Mgr., Scovill Mfg. Co., 1446 Broad St. Sta. Bldg.
MAXFIELD, Daniel E. ('14), Sales Engr., Stokes & Smith Co., 4900 Summerdale Ave.
MAXWELL, Geo. L. ('27), Asst. Supt., Gas Transmission & Distribution, Philadelphia Elec. Co., 9th & Sansom Sts., Philadelphia; *for mail,* 208 E. 4th St., Lansdale.
McBRIDE, Thos. C. ('08), Cons. Engr., R. R. Dept., Worthington Pump & Mchy. Corp., 1616 Walnut St.
McCARTHY, Justin J. (J'29), Sales Engr., Cochrane Corp., 17th & Allegheny, Philadelphia, Pa.; *for mail,* 228 Eutaw Ave., Camden, N. J.
McCAUSLAND, Jas. R. ('28), Supt., Coal Bur. & Steam Heat Dept., Philadelphia Elec. Co., 1000 Chestnut St.
McCONNELL, Robt. S. ('13), Asst. Ch. Engr., Baldwin Loco. Wks., Paschall Sta.
McDONALD, Robt. Daniel (J'32), Engr., Oper. in Power House, John Wanamaker, 13th & Market Sts., Philadelphia; *for mail,* 904 Bell Ave., Yeadon.
McDOWELL, David W. (J'20), Constr. Engr., Publicker Commercial Alcohol Co., Snyder Ave. & Swanson St.; *for mail,* 235 W. Widener St.
McMEEKIN, Bowman M. ('20; '23), 4603 Primose Rd., Torresdale.
McMENAMIN, Chas. G. ('17; '35), Inspr., Shops, Rolling Equip., Pa. R. R., 30th St. Sta.; *for mail,* 6362 Sherman St., Germantown.
McNEAL, D. Raymond ('16; '25; '35), Pres. & Gen. Mgr., Andale Co., 1600 Arch St., Philadelphia; *for mail,* 308 Jericho Rd., Abington.
McQUILKIN, Geo., Jr. ('25), Cons. Engr., 2821 Richmond St., Philadelphia, Pa.; *for mail,* 22 Franklin Ave., Merchantville, N. J.
MEARS, Edw. W. ('31), Secy., Mears-Kane-Ofeldt, Inc., 1907 E. Hagert St.
MEDBERY, Roger L. (J'31), Dist. Rep., Janette Mfg. Co., 401 N. Broad St.
MELAS, Wm. (J'25), Ch. Engr., Instrument Div., Cochrane Corp., 17th & Alleghany Ave., Philadelphia; *for mail,* 176 Edgehill Rd., Bala-Cynwyd.
MERRILL, Ayres P., Jr. ('23; '35), Brierhurst Hotel, 4527 Walnut St.
MEYER, Chas. A. (J'33), Engr., Exper. Div., Westinghouse Elec. & Mfg. Co., Essington, Lester Branch P. O.; *for mail,* 5912 Cedar Ave.
MEYER, Ira L. (J'35), 2335 Germantown Ave.
MICKLE, Robt. T. ('15), Pres., Mickle-Milnor Engrg. Co., 21 S. 12th St.
MILLER, Frank Wm. ('28; '34; '35), M. E., Yarnall Waring Co., 102 E. Mermaid Lane; *for mail,* 204 E. Highland Ave.
MILLER, Fred'k Smith (J'33), Radio Tester, Philadelphia Storage Battery Co., O & Ontario Sts.; *for mail,* Arrott Arms, Apt. C4, Arrott & Leiper Sts.
MILLINGTON, Henry C. (J'30), Draftsman, Engrg. Dept, Strawbridge & Clothier, 8th & Market Sts.; *for mail,* 937 N. 26th St.
MINER, Harold L. ('17; '35), Mgr., Safety & Fire Protection Div., E. I. du Pont de Nemours & Co., Inc., 6026 DuPont Bldg., Wilmington, Del.; *for mail,* 4237 Osage Ave., Philadelphia, Pa.
MITCHELL, W. F. (J'36), Serv. Engr., Pa. Salt Mfg. Co., 1000 Widener Bldg., Philadelphia; *for mail,* 83 S. Lansdowne Ave., Lansdowne.
MONSELL, John R. (J'30), Jr. Engr., U. S. N., Bur. of Aero., Aero. Eng. Lab., Naval Aircraft Factory, Navy Yard.
MOODY, Lewis F. ('10), Prof. Hyd. Engrg., Princeton Univ., Princeton, N. J. & Cons. Engr., Baldwin-Southwark Corp., Paschall Sta., Philadelphia, Pa.; *for mail,* 146 Hodge Rd., Princeton, N. J.
MOORE, Harold T. (A'07), Asst. Mgr., Investigations & Reports Dept., Day & Zimmermann, Inc., 620 Packard Bldg.
MOREHEAD, Geo. L. ('12), V. P., Link-Belt Co., 2045 Hunting Park Ave.; *for mail,* 8322 Spring Ave., Elkins Park.
MORGAN, D. W. R. ('18; '35), Mgr., Oil Eng. Div., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 913 Strath Haven Ave., Swarthmore.
MUDD, John P. ('10; '15; '35), Personnel Supvr., Midvale Co., Nicetown.
MULROONEY, Arthur J. ('30; '35), Asst. Eng. House Foreman, Pa. R. R., 46th St. Engine House, Philadelphia; *for mail,* 313 Woodland Ave., Glen Olden.
MUNRO, Robt. W. (J'24), Dist. Mgr., Philadelphia Territory, Griscom-Russell Co., Land Title Bldg.
MURPHY, Walter Bispham ('16; '35), Dir., Plant Personnel, Atlantic Refining Co., 3144 Passayunk Ave.; *for mail,* 4211 Sansom St.
MYERS, Wm. Kurtz ('21), V. P., Charge Finance & Acctg., Mitten Mgmt., Mitten Bldg.
NAUMANN, Carl ('27; '30; '35), First Natl. Bank, 1500 Walnut St.
NEEDS, Sydney J. ('26; '33), Research Engr., Kingsbury Mch. Wks., Inc., Frankford; *for mail,* The Fairfax, 43rd & Locust Sts.
NELSON, Millard A. (J'30), Engr., Steam Condenser Div., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 800 Prospect Ave., Prospect Park.
NEWBOLD, John D., Jr. ('29), Indus. Engr., Day & Zimmermann, Inc., Packard Bldg.; *for mail,* Meadowbrook Lane, Chestnut Hill.
NEWHALL, Ezra A. ('18), 216 S. 19th St.
NIELSEN, Svend G. (J'30), 4025 Hartel St.
NUSSBAUM, Lee ('17), Prop., Pa. Engrg. Co., 1119—21 N. Howard St.; *for mail,* 315 Carpenter Lane, Germantown.
OBERHOLZTER, Paul N. (J'28), Engrg. Dept., Am. Engrg. Co., Aramingo Ave. & Cumberland St.; *for mail,* 7122 Woolston Rd.
OBERHUBER, Wm. F. ('22; '35), Supt. Maint., Philadelphia Elec. Co., 1000 Chestnut St., Philadelphia; *for mail,* 326 Windemere Ave., Drexel Hill, Lansdowne P. O.
O'BRIEN, Frank L., Jr. (J'31), Sales Engr., O'Brien Mchy. Co., 113 N. 3rd St.
O'BRIEN, Jas. K. ('30; '33), Mgr., V. P., Kleen Chem. Co., 3701 N. Broad St., Philadelphia; *for mail,* 139 Union Ave., Bala-Cynwyd.
ODENATH, Harry E. ('21), M. E., Charge Maint., Sears, Roebuck & Co., 4600 Roosevelt Blvd.
OESTERLE, Paul D. (J'29), Erector, Allen-Sherman-Hoff Co., 225 S. 15th St.; *for mail,* 142 E. Washington Lane, Germantown.
OGDEN, Nelson ('14; '35), Asst. Ch. Engr., Charge Design, Kingsbury Mch. Wks., Inc., 4320 Tackawanna St.
ORLOFF, Serge (J'36), Draftsman, Mech. Designer, Engrg. Dept., Gen. Elec. Co.; *for mail,* 1919 Arch St.
ORMONDROYD, Jesse ('31), Mgr. Experimental Engrg., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 404 Cornell Ave., Swarthmore.
ORR, J. L. ('23), Engr., United Engrs. & Constructors, Inc., 1401 Arch St.
PARET, H. Wilbur, Jr. ('29), 436 E. Montana St.
PARKER, John Clinton ('05), Pres., Lefax, Inc., 9th & Sansom Sts.
PEARSON, Lawrence J. ('31), Engr., Charge of Furniture Devel., Philco Radio & Television Corp., Tioga & C Sts.

PECKER, Jos. S. ('19; '21; '35), Owner, Jos. S. Pecker Mch. & Tool Designing Co., 1011 Chestnut St.
PENROSE, Chas. ('18), V. P., Day & Zimmermann, Inc., Packard Bldg.
PERRY, Thos. D. ('17; '25), Engr., Charge Market Devel., Resinous Products & Chem. Co., Ltd., 222 W. Washington Sq., Philadelphia, Pa.; *for mail*, 361 W. 2nd St., Moorestown, N. J.
PETERSON, John H. (J'34), 7500 Fayette St.
PETTIT, Albert R. ('34), Engr., Charge Design, Philadelphia Elec. Co., 9th & Sansom Sts., Philadelphia, Pa.; *for mail*, 44 E. Main St., Rancocas, N. J.
PEW, Jos. N., Jr. ('15; '35), V. P., Sun Co., 19th Fl., 1608 Walnut St.
PFEIFFER, Chas. G. ('13), Pres., Spec. Engrg. Co., Allegheny & Trenton Ave.; *for mail*, 1338 Pike St.
PHILLIPS, John C. ('20; '35), Ch. Engr., Benj. Franklin Hotel Corp., 9th & Chestnut Sts.
PINES, Chas. A. ('21; '35), Asst. to Refinery Supt., Charge Cracking Dept., Atlantic Refining Co., 3144 Passyunk Ave.; *for mail*, 1229 South 52nd St.
PINNEY, Clyde G. ('26; '35), Tech. Rep. South & Cent. Am., Baldwin Loco. Wks.
PLACÉ, Louis V., Jr. (J'20), V. P., Charge Gen. Offices & Sales, W. J. McCahan Sugar Refining & Molasses Co., 101 S. Front St.
PLASS, Chas. W. ('30), 826 E. Haines St.
PLUME, William F. (J'35), Draftsman, Designer, Philadelphia Gear Works, G St. & Erie Ave.; *for mail*, 884 N. Holly St.
POHLKE, Philip A. (J'29), Student Engr., Allen Sherman Hoff Co., Lewis Bldg., Philadelphia, Pa.; *for mail*, 117 Linden Ave., Collingswood, N. J.
POMEROY, T. M., Jr. (J'35), Asst. Engr., Power, Franklin Sugar Refining Co., Foot of Reed St.; *for mail*, 416 S. 41st St.
POTTER, Philip John (J'34), Engr., M. E. Div., Philadelphia Elec. Co., 900 Sansom St.; *for mail*, 107 E. Gorgas Lane.
POWELL, J. Lewis (J'33), 408 W. Walnut Lane.
PRESSY, Ralph W. ('31; '35), Ch. Engr., Pa. Hospital for Mental & Nervous Diseases, 111 N. 49th St.
PRESTON, Herbert E. ('23), Ch. Engr., Am. Engrg. Co., Sta. K.
PRICE, Morton Moore ('21), Mgr., Philadelphia Dist. Sales, Babcock & Wilcox Co., 1120 Packard Bldg.
PRIOR, John A. ('24; '35), Asst. Prof. M. E. (Design), Univ. of Pennsylvania; *for mail*, 5047 Hazel Ave.
PROPPER, Edouard M. (J'36), Sheet Metal Worker, Fleetwings, Inc., Bristol; *for mail*, 1911 W. Erie Ave., Philadelphia.
PURSEL, Harold R. ('21; '26; '35), Engr., Charge Design, Allen Sherman Hoff Co., 225 S. 15th St.; *for mail*, Penn Athletic Club, Rittenhouse Sq.
QUAST, Walter F. ('16; '26), Supvr. Prod. Costs, Philadelphia Elec. Co., 9th & Sansom St.; *for mail*, 6448 Woodcrest Ave.
QUEREAU, John F. (J'27), Engr., Devel. Sec., Leeds & Northrup Co., 4901 Stenton Ave.
QUINLAN, Philip J. ('24; '35), Exec., Colonial Knitting Mills, Inc., Clearfield & B St.; *for mail*, 531 Shoemaker Rd., Elkins Park.
QUINN, Arthur M. ('25; '35), Sales Engr., Hagar Corp., 225 S. 15th St., Philadelphia; *for mail*, 611 Rowland Ave., Cheltenham.
RABE, J. S. ('36), Engrg. Dept., Wm. Sellers & Co., Inc., 1600 Hamilton St.
RABL, Hans (J'31), Engr., Charge Design, Enterprise Mfg. Co. of Pa., 3d & Dauphin Sts.; *for mail*, 3230 N. Broad St.
RAMSDEN, John T. ('06), Ch. Engr., Charge Design & Prod., Tabor Mfg. Co., 6225 Tacony St.; *for mail*, 1911 N. 17th St.
RASMUSSEN, Rudolph Chas. ('32), Supt. Woodworking Dept., Depot of Supplies, U. S. Mar. Corps., 1100 S. Broad St.
RAU, Otto M. ('22), Consulting Engr., 1520 Locust St.
RAWSON, Arthur J. ('28; '31; '35), Assoc. in Medical Physics, Charge Design & Constr. of Apparatus, Johnson Foundation, Univ. of Pa., 36th & Spruce Sts., Philadelphia; *for mail*, 519 S. Orange St., Media.
READ, Miles H. ('26), Asst. Engr., Simplex Valve & Meter Co., 68th & Upland St.; *for mail*, 1331 S. Lindenwood St.
REHFUSS, Wm. C. ('24), Sales Engr., Schutte & Koerting Co., 12th & Thompson Sts., Philadelphia; *for mail*, 4346 Woodland Ave., Drexel Hill.
REIDL, Albert L. ('28), M. E., Charge Maint., Gen. Elec. Co., 6901 Elmwood Ave., Philadelphia; *for mail*, 518 Laurel Rd., Yeadon.
REILLY, Bertram B. (J'36), Engr., Estimator, Trilling & Montague, 2409 Walnut St.; *for mail*, 3230 Chestnut St.
REMMERS, Henri L. W. ('19; '21), Constr. Engr., Chem. Dept., Barrett Co., Margaret & Bermuda Sts.; *for mail*, 4232 Longshore St.
REPSCHA, Albert H. (J'31), Asst. Prof. M. E., Drexel Inst., 32nd & Chestnut Sts.
RICE, Clarence H. (J'33), Sales Asst., Westinghouse Elec. & Mfg. Co., 3001 Walnut St.
RICHARDSON, Robt. G. (J'30), Ch. Draftsman, Natl. Airoil Burner Co., 1327 Girard Ave.; *for mail*, 5878 N. 7th St.
RICKEY, Daniel (J'36), Student, Wharton Grad. Sch. of Finance & Commerce, Univ. of Pa., Philadelphia, Pa.; *for mail*, 490 Hallett St., Bridgeport, Conn.
RIDDELL, A. H. ('01), Mem. Firm, Machold & Riddell, Contr. Engrs., 1020 Stephen Girard Bldg., Philadelphia, Pa.; *for mail*, 245 Mountwell Ave., Haddonfield, N. J.
RIDDLE, Kenneth W. (J'29), Instr. in Shops & Drawing, Drexel Inst., Philadelphia; *for mail*, 103 N. Monroe St., Media.
RIEBENACK, Max, 3rd ('31; '35), Dist. Sales Mgr., Indus. Brownhoist Corp., of Bay City, Mich.; *for mail*, 1175 Broad St. Sta. Bldg., Philadelphia, Pa.
RIEKER, Ernest G., Jr. (J'35), Prod. Planning Dept., Atlas Ball Co., 3d & Glenwood Ave.; *for mail*, 6310 Hasbrook Ave., Lawndale.
ROBERTS, John L., Jr. (J'24), Manheim Apts. B-1, Queen Lane & King St.
ROBINSON, Dwight P. ('19), United Engrs. & Constructors, Inc., 1401 Arch St.
ROBINSON, P. A. ('24; '35), Asst. Traffic Mgr., Freihofer Baking Co., 20th & Indiana Ave., Philadelphia; *for mail*, 112 Decatur Rd., Oakmont, Upper Darby.
ROGERS, Frank H. ('17), Ch. Engr., I. P. Morris Division, Baldwin-Southwark Corp., Paschall P. O.
ROGERS, Henry S. (J'35), Foreman, Gulf Oil Corp.; *for mail*, Penn Athletic Club, Rittenhouse Sq.
ROHLIN, V. A. ('28; '35), Designing Engr., Cochrane Corp., Philadelphia; *for mail*, 271 Bickley Ave., Glenside.
ROSE, Chas. B. ('26), Asst. to Pres., Baldwin Loco. Wks., Paschall P. O.
ROSENBLATT, Maurice C. ('22; '29), Gen. Mgr., Acoustical Corp. of Am., A & Venango Sts.
ROSSETTO, Louis (J'36), Student M. E., Westinghouse Elec. & Mfg. Co., Lester Branch P. O.; *for mail*, 22 S. Robinson St.
ROTH, Geo. L. (J'34), M. E., Charge Maint., Boiler Rm., Keasbey & Mattison, Ambler; *for mail*, 612 S. 51st St., Philadelphia.
ROTH, Paul V. (J'21), Shop Engr., Leeds & Northrup Co., 4901 Stenton Ave.; *for mail*, 4931 N. 16th St.
ROWAN, Robt. L. ('26; '35), Fuel Engr., Gen. Coal Co., 2500 Fidelity Trust Bldg.
ROWAND, Ellwood M., Jr. ('20; '25), Supvr., Gas Sales, Suburban Div., Philadelphia Elec. Co., 1000 Chestnut St., Philadelphia; *for mail*, 1534 Powell St., Norristown.
RUCK, Geo. ('15; '35), Pres., Columbia Steel Equip. Co., Lincoln-Liberty Bldg.; *for mail*, 1512 Spruce St.
RUFF, Herbert ('20; '35), Engr., Charge of Research, Wm. Sellers & Co., Inc., 1600 Hamilton St., Philadelphia, Pa.; *for mail*, 29 W. Franklin Ave., Collingswood, N. J.
RUNGE, Robt. F. ('21; '28), V. P., SKF Industries, Inc., Front St. & Erie Ave.
RUST, Henry P. ('21), Harper & Taylor, Inc., 225 S. 15th St., Philadelphia, Pa.; *for mail*, Whittle Springs Hotel, Knoxville, Tenn.
SAALFRANK, J. M. ('15), Cons. Engr., 207 W. Tabor Rd.
SAILER, Jos., Jr. (J'35), Passenger Agt., United Air Lines, Municipal Airport, Chicago, Ill.; *for mail*, 1718 Spruce St., Philadelphia, Pa.
SAMANS, Walter ('20), Ch. Engr., Atlantic Refining Co., 3144 Passyunk Ave.; *for mail*, 2527 S. Lambert St.
SAMOILOFF, Leon A. (J'36), Engr., 228 S. 21st St.
SAMPTER, Herbert C. ('16; '22; '35), Indus. Engr., Charge Mfg., Blaisdell Pencil Co., 52 Church Lane.
SARAGOVITZ, Harry M. (J'33), Supvr., Scale Assembly, Philco Radio & Television Corp., C & Tioga Sts.; *for mail*, 1601 N. 33rd St.
SAUTER, Wm. V. ('19; '35), Pres., Am. Engrg. Co., Aramingo Ave. & Cumberland St.
SCHALLER, Norman C. (J'36), 324 E. Allen's Lane.
SCHANZE, Carl R. (J'36), Field Engr., W. H. & L. D. Betz, 235 W. Wyoming Ave.; *for mail*, 6315 Homer St.
SCHAUM, Otto W. ('94), Pres., Fletcher Wks., Inc., Glenwood Ave. & 2d Sts.
SCHICK, D. Fred'k, Jr. (J'31), Jr. Engr., Mech. Dept., Philadelphia Elec. Co., 1000 Chestnut St.; *for mail*, 4517 Locust St.
SCHMITT, Henry O. ('31; '35), Constr. Engr., Am. Water Softener Co., Philadelphia; *for mail*, Street Rd., Davisville.
SCHOFIELD, W. Richison ('27; '32), Ch. Engr., Leeds & Northrup Co., 4901 Stenton Ave.; *for mail*, 736 E. Phil-Ellena St.
SCHOWALTER, Clarence H. (J'26), 4101 Baltimore Ave.
SCHRANZ, Chas. A. ('18), Mgr., Mchy. Dept., R. D. Wood & Co., 400 Chestnut St.
SCHRANZ, Fred'k G. ('16), Sales Mgr., Baldwin-Southwark Corp.; *for mail*, 6416 Overbrook Ave.
SCHUSSLER, Walter H. ('21), 4600 Comly St.
SCOTT, Jas. B. ('96; '00), Power Engr., Reports Dept., Day & Zimmermann, Inc., Packard Bldg.; *for mail*, 503 S. 46th St.
SCOTT, Richard S. ('22), Cons. Engr., 1339 Commercial Trust Bldg.
SELLERS, Coleman, 3rd ('28), Exec. Engr., Wm. Sellers & Co., Inc., 1600 Hamilton St.
SEMEL, Edward (J'35), 647 S. 56th St.
SEVERS, Elmer B. ('17), Engr. Design Power, Day & Zimmermann, Inc., 620 Packard Bldg.
SHAFFER, Milton W. (J'28), Plant Engr., Am. Ice Co., 1224 Belmont Ave.; *for mail*, 1605 W. Allegheny Ave.
SHAPIRO, Chas. (J'35), Sales Engr., Johnson Serv. Co., 2853 N. 12th St.; *for mail*, 3225 Powelton Ave.
SHARP, R. E. B. ('18), Hyd. Engr., I. P. Morris Div., Baldwin-Southwark Corp.
SHELTON, Chas. L. (J'29), Textile Engr. & Research, E. F. Houghton Co., Somerset St.; *for mail*, 436 Wellesley Rd.
SHUTE, Harvey R. (J'34), 125 W. Olney Ave., Olney.
SIBSON, Walter W., Jr. (J'30), Philadelphia Drying Mchy. Co., 3351 Stokely St.
SKINNER, Jas. C. (J'33), Asst. Supvr. Track, Pa. R. R. Co., Pennsylvania Sta., 30th & Market Sts.; *for mail*, 6820 Quincy St., Germantown.
SLOAN, Wm. Allan ('21; '30), Prof. M. E., Univ. of Pa.
SMART, Richard A. ('94; '00; '06), Asst. Sales Mgr., Automatic Temperature Control Co., 34 E. Logan St.
SMILEY, Edwin ('36), Propr., Edwin Smiley Co.; *for mail*, 7 S. 15th St.
SMITH, J. F. Downie ('24; '33; '35), Asst. to Ch. Engr., Edw. G. Budd Mfg. Co., 25th St. & Hunting Park Ave.; *for mail*, 7315 Pittsville Ave.
SMITH, Norman L. ('27; '35), Estimating Engr., Link-Belt Co., 2045 Hunting Park Ave., Philadelphia, Pa.; *for mail*, 105 Ogden Ave., Collingswood, N. J.
SMITH, Persifor F., Jr. ('04), M. P. Engr., Pa. R. R., Guaranty Bldg., Philadelphia; *for mail*, P. O. Box 534, Paoli.
SMITH, Walter ('20), Plant Engr., Design & Maint., Franklin Sugar Refining Co., Foot of Reed St.; *for mail*, 139 W. Abbottsford Ave.
SMITH, Wilbur R. (A'22), Crescent Box Corp.; *for mail*, 5813 Walker St.
SNYDER, Louis F. ('27), Designing Engr., Monotype Mch. Co., 24th & Locust Sts.; *for mail*, 5318 N. 12th St.
SNYDER, W. Earl (J'32), Engr., Philadelphia Quartz Co., 121 S. 3rd St.; *for mail*, 419 S. 44th St.
SODERBERG, C. Richard ('24; '30), Mgr., Turbine Div., Westinghouse Elec. & Mfg. Co., Lester Branch P. O.
SOLOT, Kohlman (J'33), 2450 N. Napa St.
SOMERVELL, Philip A. (J'36), Sales Engr., Giles & Ransome, 17th & Sedgley Ave., Philadelphia, Pa.; *for mail*, 601 Riverbank, Riverton, N. J.
SOOKASIAN, Geo. H. (J'36), Tool & Die Designer, Edw. G. Budd Mfg. Co., 25th St. & Hunting Park Ave.; *for mail*, 3715 N. Gratz St.
SPELLMAN, Chas. B. ('18; '27), Asst. Hyd. Engr., I. P. Morris Div., Baldwin-Southwark Corp., Paschall Sta., Philadelphia; *for mail*, 116 S. Scott Ave., Glen Olden.
SQUIRES, Richard (J'31), Engr., Safety, Am. Mutual Liability Ins. Co., 772 Public Ledger Bldg.
STEEN-JOHNSEN, Hall (J'33), Engr., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail*, 4213 Fern Blvd., Drexel Hill.
STEM, Frank B. ('15), Engr. Charge Opera., United Gas Improvement Co., 1401 Arch St.; *for mail*, 220 E. Mt. Pleasant Ave.
STEPHAN, Walter N. (J'31), Designer, Engrg. Dept., Instrument Co., Wayne & Roberts Aves.; *for mail*, 135 Brown St.
STEVENS, Wm. Jas. ('29; '35), Asst. Prof. M. E., Drexel Inst., 32d & Chestnut Sts.
STINE, Saml. S. ('27; '35), Supt. Light Mfg., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail*, 188 W. Albemarle Ave., Lansdowne.
STYRI, Haakon ('25), Dir. Research, SKF Industries, Inc., Front St. & Erie Ave.
SUMNER, Eliot ('10), Asst. to Gen. Supt., Motive Power, Pa. R. R., Broad St. Sta.

SUPPLEE, Warren P. (A'18), Ch. Engr., Power Charge Constr., Opera. & Maint., Thos. Wolstenholme Sons & Co., 3300 Frankford Ave.; *for mail,* 1127 Harrison St.
SWEIGARD, Jos. L. ('23), Sole Prop., Jos. L. Sweigard & Co., 1342 Lincoln-Liberty Bldg.
SYKES, David L. (J'33), Philadelphia Storage Battery Co., Philadelphia, Pa.; *for mail,* 356 W. 34th St., New York, N. Y.
SYLVESTER, L. Arthur ('30), Cons. Mgmt. Engr., Stevenson, Jordan & Harrison, 19 W. 44th St., New York, N. Y.; *for mail,* 1101 E. Tulpehocken St., Philadelphia, Pa.
TAFEL, Robt. W. (J'35), 919 S. St. Bernard St.
TANNER, Henry C. ('24; '27; '35), Mgr., Bailey Meter Co., 622 Bulletin Bldg., Philadelphia; *for mail,* 3729 Huey Ave., Drexel Hill.
TAWRESEY, John S. ('20; '26; '35), Asst. Ch. Engr., SKF Industries, Inc., Front St. & Erie Ave., Philadelphia; *for mail,* 514 Cheltena Ave., Jenkintown.
TAYLOR, Benj. Wm. (J'22), Engr., Ry. Div., SKF Industries, Inc., Front St. & Erie Ave., Philadelphia; *for mail,* 108 Summit Ave., Jenkintown.
TERZIAN, H. G. ('14; '21; '35), Operating Gas Engr., United Engrs. & Constructors, Inc., 112 N. Broad St.; *for mail,* 5746 Walnut St.
THERIAULT, Raymond J. (J'33), Engr., Edw. G. Budd Mfg. Co., 25th St. & Hunting Pk. Ave.; *for mail,* 339 E. Sharpnack St.
THOMAS, Benj. M. ('25; '35), Gen. Mgr., Container Corp. of Am., Manayunk.
THUMIN, Carl ('23; '26; '32), Designing Engr., Gen. Elec. Co., 6901 Elmwood Ave., Philadelphia; *for mail,* 909 Tunbridge Rd., Lansdowne.
TIMMIS, Pierce ('20), Serv. Equip. Engr., United Engrs. & Constructors, Inc., 1401 Arch St., Philadelphia; *for mail,* 202 Midland Ave., Wayne.
TORREY, Donald F. (A'31), Sales Mgr., Currie & Campbell, Rm. 1101, 1700 Walnut St.
TRUMP, Chas. C. ('14; '19; '35), Pres. & M. E., Jas. Spear Stove & Htg. Co., 1823 Market St.
TYSON, J. S. Y. ('15; '35), Constr. Engr., E. T. Stotesbury, 519 Wyndmoore Ave., Chestnut Hill.
ULMANN, August, Jr. ('18; '26), Instr. M. E., Univ. of Pa.
UNIS, Max Jay (J'36), 807 S. 4th St.
VANAMAN, Francis H. ('29; '35), Engr., Charge Design, George F. Hodkinson, 6701 N. Broad St.; *for mail,* 4126 N. Castor Ave.
VAN ARTSDALEN, Jas. T. (J'26), Engrg. Asst., Sta. Operating Dept., Philadelphia Elec. Co., 1000 Chestnut St., Philadelphia; *for mail,* 152 E. Marshall Rd., Lansdowne.
VAN HORN, Chas. W. G. (J'35), 2312 N. Broad St.
VAUCLAIN, Saml. M. ('94; H'20), Vice-President, '04-'06; Chmn. Bd., Baldwin Loco. Wks., 123 S. Broad St.
VOGEL, Wm. J. ('21; '30), Sales Engr., Combustion Engrg. Co., Inc., Philadelphia; *for mail,* 117 Glenwood Rd., Merion.
WAGONER, Gillson R., Jr. ('22; '27), 1666 Conklin St.
WALKER, Donald S. ('36), Dist. Mgr., Combustion Engrg. Co., Inc., 1616 Walnut St.
WALKER, Norbert Jas. ('36), Sr. Engr., Philadelphia Elec. Co., 900 Sansom St.; *for mail,* Green Manor Apts., Greene & Johnson Sts.
WALSH, Wm. J. ('15; '22), Mgr., Delta File Wks., Bridesburg; *for mail,* 618 W. Sedgwick St., Mt. Airy.
WALTON, Albert ('29), Cons. Indus. Engr., 1008 Melrose Ave., Oak Lane.
WASHBURN, Franklin E. ('34; '35), Dist. Supt., Combustion Engrg. Co., Inc., 200 Madison Ave., New York, N. Y.; *for mail,* 6318 City Line Ave., Philadelphia, Pa.
WATSON, H. F. ('20; '35), 519 E. Tulpehicken St., Germantown.
WEAVER, Wm. E. (J'34), M. E., Charge Costs, Philadelphia Storage Battery, C & Tioga Sts., Philadelphia; *for mail,* 834 Fern Ave., Yeadon.
WEBB, Wm. Delano (J'33), Apt. A-305, 4605 Chester Ave.
WEBSTER, Howard J. ('18), Cons. Engr., Greene & Hortter Sts.
WEINBERG, Philip H. ('32), Sales Engr., Philadelphia Elec. Co., 1000 Chestnut St.
WEISS, Walter L. (J'36), 4652 N. 11th St.
WELCH, Lybrand R. (J'34), Jr. Engr., Maint., Barrett Co., 36th St. & Grays Ferry Rd., Philadelphia; *for mail,* 6814 Chestnut St., Upper Darby.
WELLS, Herbert (J'27), Sales Engr., Am. Engrg. Co., Station "K," Philadelphia; *for mail,* 7026 Clinton Rd., Upper Darby.
WENTWORTH, Reginald A. ('11; '13), Exec. V. P., Sharpe & Dohme, Broad & Wallace Sts.
WERST, Chas. W. ('09), Ch. Insp., Baldwin Loco. Wks., Philadelphia; *for mail,* 383 Kirks Lane, Drexel Hill.
WERST, Harry K. (J'26), Supt., Navy Hitensile Dept., Edw. G. Budd Mfg. Co., 25th St. & Hunting Park Ave.; *for mail,* 5052 McKean Ave.
WESCOTT, Frank L. (J'33), 6230 Limekiln Pike.
WEST, Ralph E. (J'32), Elec. Storage Battery Co., Allegheny & 19th Sts.
WESTERMAIER, Francis V. ('31), V. P., Kitson Co., 261 N. Broad St., Philadelphia, Pa.; *for mail,* 400 Kings Highway E., Haddonfield, N. J.
WESTIN, Chas. J. ('25; '35), Engr., Charge Design, F. J. Stokes Mch. Co., Tabor Rd. & Adams Ave.; *for mail,* 933 Herbert St.
WETHERILL, Fred. V. ('19; '30), Asst. Maint. Engr., Atlantic Refining Co., 3144 Passyunk Ave., Philadelphia; *for mail,* Box 43, Rosemont.
WHEELER, Clifton H., Jr. ('13), V. P., Gen. Mgr., C. H. Wheeler Mfg. Co., P. O. Box 6910 N. Philadelphia Sta.
WHITE, Wm. B., Jr. (J'30), Mech. Draftsman, Wm. Sellers & Co., Inc., 16th & Hamilton Sts.; *for mail,* 1504 S. 58th St.
WIBERG, Richard E. (J'34), 410 Manheim St.
WILLIAMS, F. Norton, Jr. (J'35), Draftsman, Ry. Div., Edw. G. Budd Mfg. Co., 25th St. & Hunting Park Ave.; *for mail,* 5722 Greene St., Germantown.
WILLIAMS, Geo. E. (J'33), Supvg. Engr., Henry Disston & Sons, Inc., Tacony St.; *for mail,* 1310 E. Columbia Ave.
WILSON, Alex., 3rd ('21), Asst. to V. P., Philadelphia Elec. Co., 1000 Chestnut St.
WILSON, Benj. Jas. ('21; '25; '29), Ch. Mech. Div., Research Dept., Leeds & Northrup Co., 4901 Stenton Ave.; *for mail,* 125 W. Mt. Airy Ave.
WILSON, Hamilton M. ('30), Owner, H. M. Wilson Co., 18th & Brandywine Sts.; *for mail,* 5653 N. 10th St.
WOAL, Samuel T. (J'34), 216 Greenwich St.
WOBENSMITH, Zachary T., 2nd (J'27), Pat. Lawyer, 519 Land Title Bldg.
WOLFF, John F., Jr. (J'18), Cons. Engr., 6826 N. 9th St.
WOLLIN, Ernest ('32; '35), Turbine Foreman, Philadelphia Elec. Co., 27th & Christian Sts.
WOOD, Albert C. ('94; '00; '04), Cons. Engr., Stock Exchange Bldg.
WOODROFFE, Geo. H. ('16), Metal. Engr., Reading Iron Co., 401 N. Broad St.
WORKER, Jos. Garfield ('14), Asst. to Pres., Gen. Sales Mgr., Am. Engrg. Co., Cumberland & Aramingo Ave.
YARNALL, D. Robt. ('03; '11; F'36), Manager, '17-'20; Co-Founder, Dir. & Ch. Engr., Yarnall Waring Co., Mermaid Lane, Chestnut Hill.
YEWDALL, Francis M. ('15; '32), Cons. Engr., M. E., E. E., 5946 N. 13th St.
YOUNG, Chas. M., Jr. ('16; '25), Designing Engr., Link-Belt Co., 2045 W. Hunting Park Ave.; *for mail,* 518 E. Johnson St., Germantown.
YOUNG, H. Russell ('28; AM'34), Engr., Charge Design, Wm. Sellers & Co., Inc., 1600 Hamilton St.
ZAUTNER, Norman G. (J'20), M. E., Gen. Elec. Co., 6801 Elmwood Ave., Philadelphia; *for mail,* 110 W. Marshall Rd., Lansdowne.
ZEINER, Eugene F. ('23; '28), 915 Packard Bldg., Philadelphia; *for mail,* 16 Rockhill Rd., Bala-Cynwyd.
ZIMMERMANN, John E. ('07; '22), Pres., United Gas Improvement Co., 1401 Broad St.

PHOENIXVILLE, Philadelphia Section

BURKE, Robt. F. ('21), Heine Boiler Co.

PITTSBURGH, Pittsburgh Section

AMBROSE, Roy B. ('13; '21), Mgr. of Bldgs. & Grounds, Carnegie Library & Inst., Schenley Park.
AMOS, C. W. ('29; '35), Draftsman, U. S. Engr. Dept., War Dept.; *for mail,* Box 1393.
ANTISELL, Frank L. ('05), 826 Savannah Ave.
APPLEGATE, Walter (J'36), Asst. to Prof. W. Trinks, Carnegie Inst. of Tech.; *for mail,* 588 East End Ave.
ASTON, Jas. ('21), Prof. Min. & Metallurgy, Head Dept. Min. & Metallurgical Engrg., Carnegie Inst. of Tech.
ATHERHOLT, Gordon M. ('21; '25), Pat. Lawyer, Gulf Oil Corp., Gulf Bldg.
AUGUSTINE, Alfred (J'36), Draftsman, Estimator, Loftus Checker Div., Union Mining Co., 507 Oliver Bldg.; *for mail,* 6815 McPherson Blvd.
AUSTIN, Walter M. ('18), Engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 2651 Pioneer Ave., Pittsburgh.
BAIRD, H. B. ('21), 1001 Koppers Bldg.
BANNISTER, Bryant ('19), Asst. to V. P., Natl. Tube Co., Frick Bldg.
BARRY, T. J. ('17; '21; '35), Mfrs. Rep., Park Bldg.
BAUDRY, Rene Andre ('35; '35), M. E., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* Cathedral Mansions, Ellsworth Ave., Pittsburgh.
BECKJORD, Walter C. (22), Columbia Gas & Elec. Corp., 800 Union Trust Bldg.
BECKWITH, Thos. G. (J'35), Instr., M. E. Dept., Univ. of Pittsburgh; *for mail,* Adrian Apt., 4629 Bayard St.
BEHAR, Maj. Manoel F. ('20; '27), Dir., Instrumentation Manuel Projects, 245 Melwood St. & Editor, "Instruments," Instruments Publ. Co., 1117 Wolfendale St.; *for male,* Loutellus Apts.
BELL, Frank B. ('18), Pres., Edgewater Steel Co., P. O. Box 249.
BENNETT, Chas. Wilbur ('04), Retired; 6300 Darlington Rd.
BIGGERT, F. C., Jr. ('15), V. P. & Sr. Engr., United Engrg. & Fdy. Co., 1st Natl. Bank Bldg.; *for mail,* 108 Hawthorne Ave., Crafton.
BISSINGER, John A., Jr. (J'27), Supt., Mch. & Forge Shops, Dravo Contrg. Co., Neville Island Sta., Pittsburgh; *for mail,* Stonedale, Sewickley Heights.
BLAISDELL, A. H. ('12; '19; '35), Assoc. Prof., M. E., Carnegie Inst. of Tech., Pittsburgh; *for mail,* 7318 Trevanion Ave., Swissvale.
BLAKESLEE, Major Doraf W. ('21), Elec. Engr., Charge Design, Allegheny Co. Authority, County Office Bldg.; *for mail,* 1211 Morningside Ave.
BLENKO, Walter J. ('21; '31), Partner, Stebbins, Blenko & Parmelee, 1319 Farmers Bank Bldg.
BOYLE, Wm. G. ('15), Engr., Charge Design, Installations & Opera., Pittsburgh Business Properties, Inc., 2222 Oliver Bldg.
BRADLEY, J. C., Jr. (J'34), Engr., Dust Control Div., Blaw-Knox Co., Blawnox; *for mail,* 1012 Sheridan Ave., Pittsburgh.
BRENNAN, James I. ('11; '17), Consultant, Admin. of Pub. Wks., Athens, Greece; *for mail,* 1600 Villanova Rd., E. Liberty, Pittsburgh, Pa.
BRESLOVE, Jos. ('06; '13), Cons. Engr., Oliver Bldg.
BRODEN, Edwin H. ('12), Mgr., Pittsburgh Dist., Am. Steel & Wire Co.; *for mail,* 132 Hawthorn St., Edgewood Park.
BROOKS, Moses Edw. ('27; '31), M. E., Aluminum Co. of Am., Gulf Bldg.; *for mail,* 3084 Eastmont Ave., South Hills.
BROSIUS, Edgar E. ('18), Pres., Edgar E. Brosius, Inc., Sharpsburg.
BUERGER, Chas. B. ('15), Gulf Bldg.
BURGESS, Chas. G. ('25; '34; '35), Dist. Mgr., Alco Products, Inc., 815 Plaza Bldg., 535—5th Ave.
BURLINGAME, Chas. R. ('20; '25), Combustion Engr., Pittsburgh Coal Co., Oliver Bldg.
BURNHAM, Leland F. ('21; '25), Professional Engr., 5910 Howe St.
BUTCHER, Alfred ('24), Steam Engr., Gulf Oil Corp.
BYRNES, Clarence P. ('23), Sr. Partner, Byrnes, Stebbins & Blenko, Farmers Bank Bldg., Pittsburgh; *for mail,* 601 Academy Ave., Sewickley.
CAMPBELL, E. Gordon ('18), Mech. Oper. Engr., Maint., Duquesne Light Co., 435—6th Ave.; *for mail,* 5270 Beelermont Pl.
CANAN, Wm. D. ('21; '26), Engr., Rust Engrg. Co., Clark Bldg.
CHESTER, John N. ('05), Sr. Partner, Chester Engrs., Century Bldg.
COLEMAN, Harry S. ('18), Asst. Dir., Mellon Inst. of Indus. Research.
COOPER, Howell C. ('12), Pres. & Gen. Mgr., Hope Natural Gas Co., 545 Wm. Penn Way.
CORNELIUS, Henry R. ('88), Life Ins. Underwriter, Edward A. Wood's Co., Frick Bldg., Pittsburgh; *for mail,* R. F. D. 1, Coraopolis.
COX, Anthony B. ('26), 3221 Piedmont Ave., Dormont, So. Hills P. O.
CRANE, J. B. ('14), Div. Mgr., Combustion Engrg. Co., Inc., 511 Wood St.
CRAWFORD, David Francis ('99; F'36), Manager, '10-'13; Cons. Engr., 5243 Ellsworth Ave.
CREDE, Chas. E. (J'36), 6533 Dalzell Pl.
CREIGHTON, Wm. S. (J'36), New Strip Mill, Mech. Dept., Jones & Laughlin Steel Corp., 3450—2nd Ave.; *for mail,* 19 Mildred St., Crafton.
CROMWELL, Howard T. ('28), Supt. Shops, Baltimore & Ohio R. R., Glenwood; *for mail,* 174 Cochran Rd., Mt. Lebanon.
DAILEY, W. H., Jr. (J'34), 238 S. Negley Ave., East End.
DAVIS, Jos. D. ('28), Fuels Chem., U. S. Bur. of Mines, Pittsburgh; *for mail,* 1307 Macon Ave., Swissvale.
DEILY, Arthur T. (J'13), M. E., Dravo Contracting Co., Neville Island; *for mail,* 5521 Darlington Rd.
DENIG, Fred ('22; '26; '35), V. P., Engrg. Constr. Div., Koppers Co., Koppers Bldg.

DENT, John A. ('11; '16; '25), Head M. E. Dept., Univ. of Pittsburgh.
DEXTER, Howard W., Jr. (J'24), Tech. Rep., Utilization Sales & Serv. Dept., Duquesne Light Co., 435—6th Ave.
DIESCHER, August P. ('22), Co-Partner, S. Diescher & Sons, 1510 Farmers Bank Bldg.
DIESCHER, Saml. E. ('15), Partner, S. Diescher & Sons, 1510 Farmers Bank Bldg.
DILLON, Sydney ('22), Ch. Engr., Carnegie-Ill. Steel Corp., 1315 Carnegie Bldg.
DORFAN, Morton I. ('28), Mgr., Dust Control Div., Charge Sales Installation Design, Blaw-Knox Co., P. O. Box 1198; *for mail,* 1217 Malvern Ave.
DREYFUS, Edwin D. ('05; '11), Engr., W. Penn Power Co., 14 Wood St.
DUNN, J. Jay ('17), Natl. Tube Co., Frick Bldg.
DUTTON, Meiric Keeler (A'31), Dir. of Research, Frank M. Knox Co., 2420 Koppers Bldg.
ELKUS, Jas. H. (J'33), Engr., Lewis Fdy. & Mch. Co., Groveton; *for mail,* Schenley Apts., Pittsburgh.
ELLIOTT, Geo. F. ('17; '25), 718 Frick Bldg.
ELLIS, Gershom P. ('20; '25), Ch. Engr., Design, Maint., Bd. Pub. Education, 341 Bellefield Ave.
ELLMAN, Louis ('21; '26), Dist. Mgr., M. H. Detrick Co., 712 Empire Bldg.
ELY, Sumner B. ('96; '01), Assoc. Prof., Power Engrg., Carnegie Inst. of Tech.; *for mail,* 5122 Pembroke Pl.
ENDSLEY, Louis E. ('13), Cons. Engr., 516 East End Ave.
ESTEP, Thos. G. ('19), Prof. M. E., Carnegie Inst. of Tech., Schenley Park.
FINDLATER, Stevenson ('27; '34; '35), Devel. Engr., Natl. Tube Co., Frick Bldg.; *for mail,* 1036 Jenny Lind Ave.
FITCH, Wm. K. ('28), Pres., Dravo-Doyle Co., 300 Penn Ave.
FLANAGAN, Walter N. ('17; '20; '30), Spec. Engr., Carnegie-Ill. Steel Co., Carnegie Bldg.; *for mail,* 3248 Eastmont Ave., S. Hills P. O.
FOX, John H. ('04), Tech. Adviser to Pres., Pittsburgh Plate Glass Co., Grant Bldg.
FROHRIEB, Louis C. ('13), Engr., Fed. Engrg. Co., 239—4th Ave.; *for mail,* 1107 Peermont Ave., Pittsburgh (16).
FRY, Lawford H. ('05), Ry. Engrg., Edgewater Steel Co., Box 478.
GALBREATH, Paul J. (J'36), Mchy. Merchant, Marr-Galbreath Mchy. Co., 55 Water St.; *for mail,* 47 Dinsmore Ave., Crafton, Pittsburgh (5).
GALLIK, Jos. J. (J'35), 1st Lieut., 508th Coast Artillery, U. S. A.; *home address,* 3109 Mission St., Pittsburgh; *for mail,* Spring Valley & Princetown Rds., Reading.
GILLING, Ethelbert Newman ('19), Ch. Draftsman, Charge Design, Continental Roll & Steel Fdy. Co., 903 Grant Bldg.; *for mail,* 901 Davis Ave., North Side.
GLASGOW, John G. ('18), Asst. Mgr., Mfg. Div., Gulf Refining Co., Gulf Bldg., P. O. Box 1214.
GLENN, Jas. R., Jr. (J'36), 212 Hazelwood Ave., Emsworth, Bellevue P. O., Pittsburgh.
GRAHAM, Frank H. ('31), Asst. Charge of Furnaces, Aluminum Co. of Am., 2400 Oliver Bldg., Pittsburgh; *for mail,* 1300 Singer Pl., Wilkinsburg.
GRIEST, E. E. ('19), V. P., Gen. Mgr., Fort Pitt Malleable Iron Co.
GRODNER, Abraham (J'27), M. E., Charge Welding, Blaw-Knox Co., Farmers Bank Bldg.; *for mail,* 5700 Munhall Rd.
GROWDON, J. P. ('35), Asst. Ch. Hyd. Engr., Aluminum Co. of Am., 801 Gulf Bldg.
HAHN, Clifford A. ('20; '33), Charge Engrg., H. J. Heinz Co., 1062 Progress St.; *for mail,* 5911 Wellesley Ave.
HALL, Ralph E. ('30), Dir., Hall Labs., Inc., 304 Ross St.
HALLER, Henry E. ('20), Pres., Natl. Valve & Mfg. Co., 3101 Liberty Ave.
HALLER, Oliver J. ('36), Pittsburgh Piping & Equip. Co., 43rd St. & A. V. R. R.
HALLOCK, John W. ('19; '22), Secy., Gen. Alumni Assn., Univ. of Pittsburgh.
HANDLOSER, Bertram F. ('18; '35), Gen. Supt., Dilworth Porter Div., Republic Steel Corp., 4th & Bingham Sts.; *for mail,* 5734 Northumberland St.
HANKISON, Lewis E. ('16; '26), Supt. Effic. Dept., W. Penn Power Co., 14 Wood St.
HARRINGTON, E. L. ('21; '35), Ch. Engr., Constr. Equip. Div., Blaw-Knox Co.
HEICHERT, H. S. ('29), Ch. Engr., Pittsburgh Plate Glass Co., 2200 Grant Bldg.
HEILMAN, Russell H. ('19; '25; '30), *Junior Award,* '22, and '24; Sr. Indus. Fellow, Mellon Inst.
HENDERSON, Herbert ('14; '16), Mgr., Engrg. & Constr. Dept., Gulf Oil Corp., P. O. Box 1166.
HENKEL, Carroll H. (J'34), Research Lab., Am. Sheet & Tin Plate Co., 210 Semple St., Oakland.
HERR, Benj. M. ('15), Owner, Herr, Harris Co., 910 Fulton Bldg.
HERTZLER, S. P. ('19), Ch. Engr., B. Floersheim & Co., 2008 Farmers Bank Bldg.; *for mail,* 3321 Francisco St.
HIBBARD, Robt. L. ('13), Cons. Engr., Jenkins Arcade.
HIMES, Walter H. ('30), Westinghouse Elec. & Mfg. Co., 200 McCandless Ave.; *for mail,* 328 Woodside Rd., Pittsburgh (21).
HOBE, John W. (J'32), Asst. Prof., Mgmt. Engrg. Dept., Carnegie Inst. of Tech., Schenley Park; *for mail,* 508 Oakwood St., Pittsburgh (21).
HOLBROOK, Elmer A. ('27), Dean, Sch. Engrg. & Mines, 104 Thaw Hall, Univ. of Pittsburgh.
HOLTZ, John C. (J'34), Assoc. Gas Engr., Exper. Sta., U. S. Bur. of Mines, 4800 Forbes St.
HOOK, C. Howard ('22), 6949 Thomas Blvd.
HOPWOOD, John W. ('22), Pres., Hagan Corp., 600 Bowman Bldg.
HOUSTON, H. A. ('13; '21), Asst. to Gen. Mgr., United Engrg. & Fdy. Co.
HOWARTH, Elbert S. (J'36), 3138 Glendale Ave., Pittsburgh (10).
HOYT, Frank W. ('15; '25), Prod. Engr., Byllesby Engrg. & Mgmt. Corp., 435—6th Ave.
HUBBARD, Jas. F. (J'34), Mill Oper., No. 18 Mill, Jones & Laughlin Steel Corp.; *for mail,* 316 Melwood St.
HUFF, Geo. F. ('26), Sales Engr., Jas. Hood Miller, 1214 Chamber of Commerce Bldg.; *for mail,* 6122 Callery St.
HUFFMAN, Samuel A. (J'27), M. E., Miller Ptg. Mchy. Co., 1117 Reedsdale St.
HUMPHREY, Arthur L. ('15), Chmn. Exec. Com., Westinghouse Air Brake Co., Wilmerding; *home address,* 361 Maple Ave., Edgewood, Pittsburgh.
HUNT, Clarkson T. ('26; '35), Asst. Eng. House Foreman, Charge Maint., Pa. R. R.; *for mail,* 6014 Stanton Ave.
HUNTER, John A., Jr. (J'33), Engr., Serv. Dept., Natl. Tube Co., Frick Bldg.; *for mail,* 856 Ohio River Blvd., Avalon, Pittsburgh.
HUNTER, John Alex. ('09), Asst. Ch. Engr., Am. Sheet & Tin Plate Co., P. O. Box 62.
JACOBSON, E. W. ('34; '35), Asst. Engr., Charge Spec. Designs, Gulf Research & Devel. Co., Drawer 2038.
JAMISON, J. A. (J'35), 302 Kenmont Ave., Mt. Lebanon.
JENKS, Stephen M. ('23; '34), Ch. Engr., Constr. Engrg. Div., Carnegie-Ill. Steel Corp., Carnegie Bldg.
JEWETT, Arthur C. ('09), 338 Masonic Temple, Portsmouth, Ohio; *home address,* 5420 Plainfield St., Pittsburgh, Pa.
JOHNSON, Chas. B. (J'22), Prod. Engr., Pittsburgh Equitable Meter Co., 400 N. Lexington Ave.; *for mail,* 219 East End Ave.
JOLLY, Thos. D. ('28), Pur. Agt., Aluminum Co. of Am., Gulf Bldg.
KARPOV, A. V. ('35), Designing Engr., Aluminum Co. of Am., 801 Gulf Bldg.
KAVENY, Thos., Jr. ('28; '34; '35), V. P., Herman-Pneumatic Mch. Co., 806 Union Bank Bldg.
KECK, Paul U. ('27; '30; '35), Neville Island Wks., Davison Coke & Iron Co., Pittsburgh; *for mail,* 1702 Ridge Ave., Coraopolis.
KELLY, Harry J. ('23), Gulf Refining Co., P. O. Box 1166.
KRIDER, Harry R. (J'33), Clerk, Credit Office, Gimbel Bros., 6th & Smithfield Sts.; *for mail,* 314 S. Aiken Ave.
KROMER, Wm. F. ('24), M. E., H. K. Porter Co., 49th St.
LADD, Geo. T. ('96; '01; '21), Pres. & Gen. Mgr., United Engrg. & Fdy. Co., 1st Natl. Bank Bldg.
LANE, Abbot A. ('17; '24; '35), M. E., Gulf Research & Devel. Co., P. O. Box 2038.
LARSEN, G. Sinding ('29), Engr., Pittsburgh Piping & Equip. Co., 43d St. & A. V. R. R.
LASSMAN, Benj. ('20; '35), Hyd. Engr., Oliver Bldg.
LEEDS, Chas. C. ('28), Prof. Mgmt. Engrg., Carnegie Inst. of Tech.
LEITZELL, F. O. ('28), V. P., Lewis Fdy. & Mch. Co.
LEONARD, Guy L. (J'36), Engr., Pittsburgh Annealing Box Co., 801 Beaver Ave., North Side.
LEWIS, Harvey H. (J'29), 501 Florence Ave., Avalon.
LINCOLN, Rollo Basil ('35), Pittsburgh Testing Lab.
LITTLER, Carl W. ('25), Ch. Engr., Jones & Laughlin Steel Corp.
LYTLE, W. O. ('30), Secy., Cent. Research Dept., Pittsburgh Plate Glass Co., Grant Bldg.
MAGILL, Franklin Robert ('17; '23), Sales Rep., Chicago Rawhide Mfg. Co. & H. A. Brassert & Co., Chicago, Ill. & Trabon Engrg. Corp., Cleveland, Ohio; *for mail,* 327 1st Ave., Pittsburgh, Pa.
MANN, Harvey B. ('11; '18), Propr., Mann Engrg. Co., 530 Duquesne Way; *for mail,* 7300 Brighton Rd., Ben Avon, Pittsburgh (2).
MATTSSON, Arne L. ('28; '35), Designer, Gulf Oil Corp., Gulf Bldg.; *for mail,* 5428 Baum Blvd.
MAYERS, Martin A. (J'27), Coal Research Lab., Carnegie Inst. of Tech., Schenley Park.
McCALLISTER, Edgar W. ('12), Pat. Lawyer, Green & McCallister, 3216 Grant Bldg.
McCLINTOCK, Allan P. ('13; '20), Sales, Beckwith Mchy. Co., 6550 Hamilton Ave.; *for mail,* 2810 Philadelphia Ave., Dormont.
McCLINTOCK, Frank S. ('20), Ch. Engr., Dravo Doyle Co., 300 Penn Ave.; *for mail,* 805 Amberson Ave.
McCONNELL, Malcolm R. ('25; '34; '35), Sales Engr., W. Penn Power Co., 14 Wood St.; *for mail,* 260 Woodhaven Dr., Mt. Lebanon.
McCULLOUGH, W. T., Jr. ('20; '26; '35), Dist. Mgr., Babcock & Wilcox Co., 2730 Koppers Bldg.
McFADDEN, Benj. C. ('20), Ch. M. E., Aluminum Co. of Am., 801 Gulf Bldg.
McLAIN, Benj. (J'34), Carnegie-Ill. Steel Corp.; *for mail,* 5860 Bartlett St.
McMILLEN, Albert K. ('13), Ch. Engr., Alex. Laughlin & Co., 1801 1st Natl. Bank Bldg.
McNULTY, Dwight L. ('21; '30), M. E., Charge Design, Engrg. Constr. Dept., Duquesne Light Co., 435—6th Ave.; *for mail,* 510 Hillcrest Pl., Mt. Lebanon.
McQUISTON, Wm. Bryce (J'26), Sales Engr., Sanford C. Smith Refractories, Inc., 1715 Niagara St., Buffalo, N. Y.; *for mail,* 406 Renshaw Bldg., Pittsburgh, Pa.
MILLER, Robt. A. ('31), Tech. Sales Engr., Pittsburgh Plate Glass Co., 2200 Grant St.
MOLINE, Adolph A. ('31; '35), Mfg. Engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail,* 150 Washington St., Edgewood, Pittsburgh.
MOORE, Wm. E. ('03), Pres., W. E. Moore & Co., Engrs., P. O. Box 1125.
MULERT, Justus L. (J'31), Treas., Mulert Securities Co., 239—4th Ave.; *for mail,* 84 Woodhaven Dr., Pittsburgh (16).
NEWHALL, W. L. (J'30), Design Draftsman, Dravo Contrg. Co., Pittsburgh; *for mail,* 1312 Vance Ave., Coraopolis.
NICHOLLS, Percy ('31), Supvg. Engr., Fuels Sec., U. S. Bur. of Mines, 4800 Forbes St.
NILSON, J. Henry ('23; '28), 29 Afton Ave., Crafton Sta.
NOBLE, Robt. E. (J'15), Engr., Rolling Mill Dept., Mesta Mch. Co.
NORRIS, Edson R. ('06), 542 Braddock Ave.
OBERG, Wm. O. (J'36), 1121—6th St., Lorain, Ohio; *for mail,* 963 Flemington St., Pittsburgh, Pa.
OVERTON, Ralph M. ('24; '30), Power & Fuel Engr., Natl. Tube Co., Frick Bldg.
PARKER, Humphrey F. ('30), Devel. Engr., Bendix-Westinghouse Automotive Air Brake Co., 5001 Centre Ave.; *for mail,* 4720 Centre Ave.
PARMLEY, Seba M. ('20), Preparation Engr., Pittsburgh Coal Co., 8 Market St.; *for mail,* 210 Castle Shannon Rd.
PEEBLES, T. A. ('12), V. P., Hagan Corp., 502 Bowman Bldg.
PHILLIPS, Wm. Hopestill ('30), V. P., Charge Sales, Molybdenum Corp. of Am., 2911 Grant Bldg.
PIGOTT, R. J. S. ('12; '13; '18), Vice-President, '36-'38; Staff Engr., Gulf Research & Devel. Co., P. O. Box 2038.
PINKERTON, Andrew ('92), Retired E. E., U. S. Steel Corp.; *for mail,* 6605 Virginia Ave., Ben Avon.
PINKNEY, David H. ('15), Asst. to V. P., Charge Engrg., Natl. Tube Co., 1714 Frick Bldg.
PLAGWIT, Eric ('18), Rust Engrg. Co., 1005 Clark Bldg.
POTE, Kenneth E. ('20; '25; '35), Dist. Mgr., Riley Stoker Corp., 239—4th Ave.
POWELL, Clarence E. ('29), Rep., R. D. Wood Co., 400 Chestnut St., Philadelphia; *home address,* 132 S. Euclid Ave., Bellevue, Pittsburgh.
POWELL, Morgan A. (J'27), Plant Supt., Vulcan Detinning Co., Neville Island P. O.
PURCELL, Thomas E. ('33), Gen. Supt. Power Stas., Duquesne Light Co., 435—6th Ave.
RAISIG, Chas. L. ('18; '35), Ch. Engr. of Sales, Mesta Mch. Co., Homestead; *for mail,* Park Hill, R. D. 1, Coraopolis.
RANDOLPH, Dale N. ('23), Mgr., Water Purifying Dept., Wm. B. Scaife & Sons Co., 26 Ann St., Oakmont; *home address,* 5024 Liberty Ave., Pittsburgh.
REED, Edwin A. (J'29), Test Engr., Duquesne Light Co., 435—6th Ave.; *for mail,* 622 Barclay St., Forest Hills.
REED, Van A., Jr. ('15), Secy. & M. E., Fed. Engrg. Co., 239—4th Ave.

RICE, Cyrus Wm. ('15), Pres., Cyrus Wm. Rice & Co., Inc., 1310 Highland Bldg.
RICE, Wm. E. ('27; '35), Assoc. Fuel Engr., Research, U. S. Bur. of Mines, 4800 Forbes St.
RITTMAN, W. F. ('19), Cons. Engr., 5705 Solway St.
ROCKWELL, Theo. F. (J'29), College of Indus., Carnegie Inst. of Tech.
ROCKWELL, Willard P. ('13; '19; '21), Pres., Pittsburgh Equitable Meter Co., 400 N. Lexington Ave.
ROPER, Chas. G. (J'36), Apprentice, Gen. Field Wk., Rust Engrg. Co., Clark Bldg., Pittsburgh, Pa.; *for mail*, 734 S. Sycamore, Petersburg, Va.
ROWLEY, Millard C. (J'24), 1411 Wightman St.
RUST, Geo. M. (J'31), Engr., Rust Engrg. Co., 1005 Clark Bldg.
RUST, S. Murray, Jr. (J'34), 1171 Murrayhill Ave.
RYAN, Jas. H. ('20; '24), Mgr., Motor & Tank Car Equip., Gulf Refining Co., Gulf Bldg., P. O. Box 1214.
SAWYER, Harold T. (J'35), 1127 Arkansas Ave., Dormont.
SAYLOR, David C. ('32), Asst. Prof. M. E., Carnegie Inst. of Tech.
SCHARNBERG, Lester N. (J'22), Asst. Steam Engr., Gulf Oil Corp., Gulf Bldg.
SCHREIBER, John W. ('14; '35), M. E., Aluminum Co. of Am., 2402 Oliver Bldg.; *for mail*, 6320 Burchfield Ave.
SCHUETTE, Robt. W. ('18; '25), Sales Engr., Pittsburgh Rep., Messinger Bearings, Inc., Philadelphia; *for mail*, 316 Akron Ave., Mt. Lebanon, Pittsburgh.
SCHWERIN, Frank H. ('29), Mgr. Engrg., Duff-Norton Mfg. Co., Preble Ave., North Side; *for mail*, 161 N. Sprague Ave., Bellevue P. O.
SCOTT, Warren R. ('29), M. E., Maint., Scott Realty, Inc., 435 Diamond St.
SEAVER, Kenneth ('14), V. P., Charge Sales, Harbison-Walker Refractories Co., Farmers Bank Bldg., Pittsburgh; *for mail*, Hulton Rd., Oakmont.
SEWELL, J. G. Clifton ('92; '25), Retired; 77 Dinsmore Ave., Crafton P. O.
SHIPLEY, Grant Batchelder (A'07), Chmn. Bd. Dirs., Wood Preserving Corp., 3010 Koppers Bldg.
SIDNEY, Wm. E. ('28), Sr. Engr., Charge Design Div., War Dept., Corps of Engrs., U. S. A., Pittsburgh Dist., New Federal Bldg.; *for mail*, 93 Linshaw Ave., Ingram.
SKAGEN, Sverre ('31), Designing Engr., M. E., Koppers Constr. Co., Koppers Bldg.; *for mail*, 1430 Mellon St.
SMILEY, Chas. B. (J'26), Constr. Engrg. Dept., Carnegie-Ill. Steel Corp., Carnegie Bldg.; *for mail*, 1822 Warriors Rd., Crafton.
SMITH, Earle E. ('24; '30; '35), Dir. Serv., Charge Field Engrg., Natl. Tube Co., Frick Bldg.; *for mail*, 3955 Bigelow Blvd.
SMITH, Geo. Wetherall ('29; '35), Gen. Mgr., Hagan Corp., 502 Bowman Bldg.; *for mail*, 1121 Wightman St.
SMITH, John Hays ('22), 6521 Darlington Rd.
SNYDER, John Adam ('21), Ch. Inspr., Hartford Steam Boiler Inspec. & Ins. Co., 56 Prospect St., Hartford, Conn.; *for mail*, 424 Jucunda St., Pittsburgh, Pa.
SOARS, John W. (J'34), Draftsman, Jones & Laughlin Steel Corp.; *for mail*, c/o Thompson, 2329 Perrysville Ave.
SOMMERVILLE, David P. (J'30), 2403 Maple Ave.
SPELLER, Frank N. ('20), Dir., Metal. & Research., Natl. Tube Co., 1810 Frick Bldg.
SPERLING, Geo. E. ('27), Ch. Engr., Cent. Engrg. Dept., Natl. Tube Co., 1715 Frick Bldg.
STEWART, Reid T. ('94), Prof. Emeritus, M. E., Univ. of Pittsburgh, Pittsburgh, Pa.; *for mail*, 312 N. E. 15th Ave., Ft. Lauderdale, Fla.
STINSON, L. S. ('22; '30; '35), Sales Engr., Elliott Co., Jeanette; *for mail*, Addison Hall, 131 Edgewood Ave., Edgewood, Pittsburgh.
STONE, Morris ('35; '35), M. E., United Engrg. & Fdy. Co., 1st Natl. Bldg.; *for mail*, 1269 Dunffield St.
STRAUB, Theo. A. ('13), Fort Pitt Bridge Wks., Oliver Bldg.
STUCKI, Arnold ('07), Pres., A Stucki Co., Oliver Bldg.; *for mail*, 42 N. Howard Ave., Bellevue.
SWANBERG, F. L. ('02; '14), Gen. Mgr., Kehota Min. Co., Rm. 1610, 1st Natl. Bank Bldg.
SWOPE, Bruce M. (J'13), Supt. M. P., West Pa. Gen. Div., Pa. R. R., Rm. 312, Pa. Sta.; *for mail*, Royal York Apts., Bigelow Boulevard at Dithridge.
SYMONDS, Nathaniel G. ('05; '15), V. P., Charge Sales, Westinghouse Elec & Mfg. Co., E. Pittsburgh; *for mail*, Schenley Apts., Pittsburgh.
TABER, Geo. H. ('94), 4114 Bigelow Blvd., Pittsburgh (13).
TALLMAN, Wm. S. (A'19), V. P., Gen. Mgr., H. H. Robertson Co., 2000 Grant Bldg.
TANNER, J. Roy ('20), Pres., Pittsburgh Valve Fdy. & Constr. Co., Box 1016.
TATTERSALL, Leo. ('24), Ch. Engr., Jas. H. Reed Power Sta., Duquesne Light Co., 435—6th Ave.; *for mail*, 410 McCully St., S. Hills.
TAYLOR, J. G. ('29), Editor, Aluminum Co. of Am., 801 Gulf Bldg.; *for mail*, 440 Olympia Rd.
TEICHMANN, Henry F. ('16; '26), Secy.-Treas., Forter-Teichmann Co., Martin Bldg., North Side.
TEWS, Bernhard F. W. ('35; '35), 346 Spahr St.
THIESSEN, Linwood (J'35), Jr. Engr., Pittsburgh Rys., 6th Ave.; *for mail*, 1114 Wightman St.
THOMAS, Jos. E. ('27), Gen. Supt. Opera., W. Penn Power Co., 14 Wood St.; *for mail*, 129 S. Braddock Ave.
THOMPSON, John I. ('18), Pres., Koppers-Rheolaveur Co., Koppers Bldg.
TRACY, Stephen J., Jr. ('29; '36), Instr. M. E. & M. E., Charge Heat Power, Univ. of Pittsburgh; *for mail*, 6504 Rosemoor St.
TRESCHOW, Kenneth F. (A'36), Exec. Secy., Engrs. Soc. of West Pa., Wm. Penn Hotel.
TRINKS, W. ('05), Prof. M. E., Carnegie Inst. of Tech.
ULRICH, Rudolf ('25; '27; '30), V. P., Charge Sales, Bacharach Indus. Instrument Co., 7000 Bennett St.; *for mail*, 120 N. Linden Ave.
VAUX, H. K. (J'35), 630 Crysler Ave., S. Hills.
WAGENSEIL, Edgar W. ('16), Gen. Sales Mgr., Hagan Corp., 502 Bowman Bldg., Pittsburgh; *for mail*, 416 Isabella St., Oakmont.
WAHRENBURG, Lester E. F. (J'26), Peter F. Loftus, Cons. Engrs., 541 Oliver Bldg.
WESCOTT, Blaine B. ('29), Engr. of Tests, Gulf Research & Devel. Co., Box 2038.
WEYMOUTH, Thos. R. ('10; F'36), Vice-President, '30-'32; V. P., Columbia Gas & Elec. Corp., 800 Union Trust Bldg.
WHETZEL, J. Clyde ('30), Asst. to V. P., Charge Opera., Am. Sheet & Tin Plate Co., Frick Bldg.
WIKANDER, Oscar R. ('19), *Melville Medallist*, '35; M. E., Ring Spring Dept., Edgewater Steel Co.
WILDIN, Geo. W. ('01), Cons. Engr., Westinghouse Air Brake Co., Rm. 207, Westinghouse Bldg.
WILKENFELDT, John W. (J'29), Jr. Engr., Engrg. & Constr. Div., Koppers Co., Koppers Bldg.; *for mail*, 948 Norwich Ave., Brookline.
WILLS, J. G., Jr. (J'34), Metallurgist, Charge Welding, Blaw-Knox Co., Blawnox; *for mail*, 238 S. Negley Ave., Pittsburgh.
WILSON, Warden F. (J'29), Mgr., Am. Steel Fdys.
WILSON, Warren M. (J'35), Sales Engr., Homestead Valve Mfg. Co., Carnot Rd., Coraopolis; *for mail*, 3414 Allendale St., Pittsburgh (4).
WOOD, Henry H. ('28), Engr., Morgan Constr. Co., 2028 Koppers Bldg.; *for mail*, 160 Inglewood Dr., S. Hills.
WRIGHT, Edwin C. ('30), Metal., Natl. Tube Co., Frick Bldg.

PITTSTON, Anthracite-Lehigh Valley Section

BERNINGER, Robt. D. ('32; '35), Results Engr., Stanton Oper. Co., Box 381.
HUBBELL, Chas. W. ('13), 48 Spring St.

PLYMOUTH, Anthracite-Lehigh Valley Section

TALLGREN, Walter ('28; '35), Steam Engr., Luzerne County Gas & Elec. Corp., 247 Wyoming Ave., Kingston; *for mail*, 43 Willow St., Plymouth.

POTTSTOWN, Philadelphia Section

JONES, David T. ('98; '04), Gen. Mgr., Wilbraham-Green Div., Roots-Connersville Blower Corp.; *for mail*, 818 High St.
LOUGHRAN, John J. ('20; '31), Plant Engr., Doehler Die Casting Co.; *for mail*, 815 N. Franklin St.
SONN, Fred W. ('27; '35), Prod. Mgr., Charge Design Devel. & Pur., Automatic Elec. Heater Co., Cross & Keim Sts.; *for mail*, 612 Spruce St.
STOUFFER, C. S. ('19), Wks. Engr., Stanley G. Flagg & Co., Inc., Stowe; *for mail*, 1000 N. Charlotte St., Pottstown.

POTTSVILLE, Anthracite-Lehigh Valley Section

HAGERTY, Walter W. ('05; '19), 2121 W. Market St.
LOTZ, Chas. W. ('21), 1502 W. Norwegian St.
SHANNON, Francis P. (J'32), M. E. in Refrig., Philadelphia & Reading Coal & Iron Co.; *for mail*, 1814 Mahan Tongo St.
SMITH, J. Darrell ('30), Mech. Engrg. Dept., Philadelphia & Reading Coal & Iron Co.; *for mail*, 317 N. 19th St.

PRIMOS, Philadelphia Section

JOHNSON, Allen J. ('35), Dir., Anthracite Inst. Lab., Primos, Del. Co.

PROSPECT PARK, Philadelphia Section

CHURCHILL, Arnold J. (J'36), Jr. Engr., Turbine Div., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail*, 640—14th Ave., Prospect Park.
DE-RENTIIS, Augusto ('31; '35), Mech. Designing Engr., Pusey & Jones Corp., Wilmington, Del.; *for mail*, 645—14th Ave., Prospect Park, Pa.
MACALLISTER, John W. ('36), M. E., Charge Maint., Scott Paper Co., Chester; *for mail*, 615—8th Ave., Prospect Park.
PEGRAM, Wm. B. (J'34), Jr. Engr., Steam Calculations, Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail*, 913 Lincoln Ave., Prospect Park.

RADNOR, Philadelphia Section

ATTERBURY, Geo. R. (J'35), Student, Harvard Sch. of Business Admin., Cambridge, Mass.; *for mail*, Radnor, Pa.

READING, Anthracite-Lehigh Valley Section

BEIRNE, John J. (J'27), 920 N. 4th St.
BENOIT, Lester W. (J'25), Engr., Charge Design, Reading-Pratt & Cady Co., Inc.
BILLICH, Wm. H. (J'28), Asst. Engr., E. M. Gilbert Engrg. Corp., 412 Washington St.; *for mail*, 2008 Steuben Rd.
BINGAMAN, Chas. A. ('29), M. E., Reading Co., 6th & Perry Sts.; *for mail*, 936 N. Front St.
BOAS, Robt. H. ('29), M. E., Charge Design, E. M. Gilbert Engrg. Corp., 412 Washington St.
DECHANT, F. H. ('20), Mem., Wm. H. Dechant & Sons, 632 Washington St.
FOX, Franklin H. (J'34), Power Engr., E. M. Gilbert Engrg. Corp., 412 Washington St.; *for mail*, 232 N. 5th St.
FRIES, Geo. S. ('27; '35), Engr., E. M. Gilbert Engrg. Corp., Reading; *for mail*, Jacksonwald.
GANGEWERE, Ernest P. ('22; '28; '35), Asst. Supt., Loco. Shop, Reading Co., 6th & Perry Sts.; *for mail*, 1417 Linden St.
GILBERT, Ernest M. ('16), Pres., E. M. Gilbert Engrg. Corp., 412 Washington St.
GILL, Chas. A. ('21), Supt. M. P. & R. E., Charge Maint. & Design, Reading Co., 6th & Perry Sts.
GODOROV, Saml. J. (J'31), V. P., Charge Finance Counsel, Indus. Fiscal Co., 521 Franklin St.; *for mail*, 2523 Philmay Terrace, Mt. Penn.
HEINE, Francis A. ('34), Asst. Ch. Engr., Bur. of Water.
ISCHINGER, Alfred E. ('27; '31), Pat. Atty., Charge Pat. Dept., Textile Mch. Wks.; *for mail*, 328 Carsonia Ave., Mt. Penn.
KLINE, J. LeRoy (J'31), Pat. Atty., Textile Mch. Wks.; *for mail*, Box 100 R. D. 2.
MATZ, Chas. L. (J'35), Prod. Engr., Vanity Fair Silk Mills, P. O. Box 875; *for mail*, 555 N. 5th St.
POOLE, Ernest J. ('15), V. P., Charge Prod., Carpenter Steel Co., 101 W. Bern St.
POWELL, Jas. A. ('27), V. P., Asst. Ch. Engr., E. M. Gilbert Engrg. Corp., 412 Washington St.
RINK, Geo. W. ('07), M. E., Reading Co.; *for mail*, 1309 Garden Lane, Wyomissing Park.
SAUNIER, Wm. P. ('29), Asst. M. E., E. M. Gilbert Engrg. Corp., 412 Washington St.; *for mail*, 132 W. Windsor St.
SPERRY, S. M. ('28), Test Engr., E. M., Gilbert Engrg. Corp., 412 Washington St.; *for mail*, 1414 Palm St.
VETLESEN, Hans J. ('26; '35), Sponsor Engr., E. M. Gilbert Engrg. Corp., 412 Washington St.
WENTZEL, Arlan L. (J'34), 843 Weiser St.

RIDGWAY, Central Pennsylvania Section

ECCLESTON, R. C. ('19), Charge Navy Contracts, Elliott Co.; *for mail*, 506 Kearsarge Ave.
GAITHER, Robt. H. ('18), V. P., Gen. Mgr., Elliott Co.
TAYLOR, Norman (J'36), Testman, Elec., Elliott Co.; *for mail*, 307 Walnut St.

RIDLEY PARK, Philadelphia Section

BATES, Harry H. ('16; '18; '23), Wks. Engr., Charge Power, Constr. & Maint., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail*, 309 Shaw Rd., Ridley Park.
HALLER, Karl R. (J'23), Ch. Engr., Mgr. East. Dist., L. G. DeQuasie & Co., 231 S. LaSalle St., Chicago, Ill.; *for mail*, Ridley Manor, Ridley Park, Pa.
MALEY, Fred'k M. ('23), Dist. Mgr., Gorham Tool Co., 14400 Woodrow Wilson Blvd., Detroit, Mich.; *for mail*, 11 W. Hinkley Ave., Ridley Park, Pa.

O'BRIEN, E. M. (J'35), 40 W. Ridley Ave.
O'BRIEN, Issac K. ('21; '35), M. E. Research & Devel., Atlas Powder Co., Delaware Trust Bldg., Wilmington, Del.; *home address,* 40 W. Ridley Ave., Ridley Park, Pa.
PALMER, Everett ('22; '35), Sta. Supt., Chester Sta., Philadelphia Elec. Co., 1000 Chestnut St., Philadelphia; *for mail,* 403 Morton Ave., Ridley Park.
THOMAS, Vincent P. (J'33), 107 E. Ridley Ave.
WERNER, Fred'k Wm. (J'33), 307 Pomeroy St.

ROCHESTER, Pittsburgh Section

BALDWIN, Richard S. (J'34), Draftsman, Steel Forms Dept., Koppel Indus. Car & Equip. Co., Koppel; *for mail,* 377 Connecticut Ave., Rochester.
FRY, Henry Skillman ('15; '35), Gen. Factory Mgr., H. C. Fry Glass Co.; *for mail,* 334 Deer Lane.
KOVACH, Andrew J. ('23; '24; '35), Draftsman, Jones & Laughlin Steel Corp., Aliquippa; *for mail,* 505 Case St., Rochester.

ROCKLEDGE, Philadelphia Section

BRUSCA, Jos. L. ('30; '31; '35), 103 Loney St.

ROHRSBURG, Anthracite-Lehigh Valley Section

LEWIS, Dean E. (J'36).

ROYERSFORD, Philadelphia Section

SCHNEIDER, Frank H. ('28; '36), Engr., Floyd-Wells Co.

RURAL VALLEY, Pittsburgh Section

VEIT, Carl J. (J'36), Box 171.

SAINT DAVIDS, Philadelphia Section

MAULL, Wm. R. ('21; '28), V. P., Dill & Collins, Inc., Richmond & Tioga Sts., Philadelphia; *for mail,* St. Davids.

SAINT MARYS, Central Pennsylvania Section

ELLSON, H. S. ('22; '35), Asst. Ch. Engr., Speer Carbon Co.

SCHNECKSVILLE, Anthracite-Lehigh Valley Section

DIBBLEE, Harold J. (J'32,) Dist. Engr., Sales & Serv., W. H. & L. D. Betz, 235 W. Wyoming Ave., Philadelphia; *for mail,* P. O. Box 34, Schnecksville.

SCRANTON, Anthracite-Lehigh Valley Section

BROOKS, Chas. W. (J'35), 1549 Jefferson Ave.
CLEMENS, A. B. ('04), Dir. Mech. Schs., Internatl. Correspondence Schs., 1001 Wyoming Ave.
COHEN, Albert A. (J'36), Highway Engr., Wks. Progress Admin., 636 Pine St.; *for mail,* 1409 Adams Ave.
FARNHAM, Geo. W. ('16; '25; '35), Mgr., College Dept., Internatl. Textbook Co., 1001 Wyoming Ave.
HOPP, Harold (J'30), 1043 N. Irving Ave.
HUSS, Harry O. (J'34), Instr., Sch. of Shop Practice, Internatl. Correspondence Schools; *for mail,* 623 N. Washington Ave.
JONES, Henry C. (J'34), Draftsman, Del., Lackawanna & West. R. R. Co.; *for mail,* 1316 Vine St.
LAUDIG, John B. (J'27), Test Engr., Stanton Oper. Co., Box 381, Pittston; *home address,* 845 Prescott Ave., Scranton.
LESSER, W. H. ('11; '14), E. E., M. E., James H. Pierce & Co.; *for mail,* 900 Clay Ave.
LOOTENS, Edw. D. (J'35), Engr., Charge Time Study, Consltd. Molded Products Corp., 309 Cherry St.; *for mail,* 719 Mulberry St.
McKNIGHT, Chas. H. ('28), Supt. Power Plants, Scranton Elec. Co.; *for mail,* 1625 Vine St.
MOORE, Fred'k L. ('23), 636 N. Washington Ave.
O'MALLEY, John F. (J'30), Jr. Engr., Scranton Elec. Co., Scranton; *for mail,* 24 Sand St., Carbondale.
PALMER, Shepard Brown, Jr. (J'34), Draftsman, Delaware, Lackawanna & West. R. R. Co.; *for mail,* 1126 Mulberry St.
ST. JOHN, Chas. E. ('25), M. E., Glen Alden Coal Co., 310 Jefferson Ave.; *for mail,* 1125 Ash St.
SAVARO, V. Gregory (J'34), 803 Woodlawn St.
SCHULZ, Donald D. ('36), Results Engr., Scranton Elec. Co.; *for mail,* 2016 Capouse Ave.
SMITH, Elliott E. ('25), M. E., Charge Opera. & Maint., Surburban Plant, Scranton Elec. Co.; *for mail,* 1516 N. Webster Ave.

SHADE GAP, Central Pennsylvania Section

LACY, Robt. ('17; '35), Shade Gap, Huntington Co.

SHARON, Youngstown Section

CARROLL, Martin J. (J'30), Combustion Engr., Wheatland Tube Co., Wheatland; *for mail,* 1534 E. State St., Sharon.
SHANOR, Edgar E. ('23), Ch. Engr., Petroleum Iron Wks.
SHIRK, Willis F. (J'36), M. E., Westinghouse Elec. & Mfg. Co.; *for mail,* 279 S. Oakland Ave.
WARREN, Geo. S. ('31), Ch. Engr., Sharon Steel Corp; *for mail,* 936 Alcoma St.

SHARON HILL, Philadelphia Section

KUCHLER, T. C. ('29; '35; '35), Huhn-Packing Co., 89 Barker Ave.

SHAWNEE-ON-DELAWARE, Anthracite-Lehigh Valley Section

WORTHINGTON, Chas. C. ('82), Manager, '83-'86.

SHEFFIELD, Erie Section

WELCH, Herman P. ('30), Gen. Mill Supt. & Maint. Engr., Cent. Pa. Lumber Co., Box 241; *for mail,* Sheffield, Warren Co.

SKYTOP, Anthracite-Lehigh Valley Section

GRADY, Chas. B. ('14), P. O. Box 96.

SPRINGDALE, Pittsburgh Section

MARTIN, Rinaldo E. ('25; '35), Supt. Power Stas., W. Penn Power Co.; *for mail,* 180 Center St.

STATE COLLEGE, Central Pennsylvania Section

ALLEN, Chas. Lellan ('23), Asst. Prof. M. E., Pa. State College; *for mail,* 711 N. Allen St.
BRADFORD, Louis J. ('14; '21), Prof. Mch. Design, Pa. State College; *for mail,* 602 Pugh St.
BULLINGER, Clarence E. ('24; '35), Prof., Head Dept., Indus. Engrg., Pa. State College; *for mail,* 637 W. Foster Ave.
COLGATE, Saml. B. (J'25), Assoc. Prof. Indus. Engrg., Pa. State College; *for mail,* 814 W. Foster Ave.
DEJUHASZ, Kalman J. ('31), Assoc. Prof., Engrg. Research, Pa. State College; *for mail,* 730 N. Atherton St.
EVERETT, Harold A. ('22), Prof., Head of Dept. M. E., Pa. State College.
GUILLET, Geo. L. ('26), Prof. M. E., Pa. State College; *for mail,* 130 N. Gill St.
HECHLER, Fred G. ('15; '29), Prof. Engrg. Research, Pa. State College; *for mail,* 343 E. Prospect Ave.
HENSHALL, P. P. ('15; '20; '35), 312 Hillcrest Ave.
HENSZEY, Jos. W. ('18), Cons. Engr., 320 Hamilton Ave.
HUMMEL, J. O. P. (J'30), Asst. Prof., Pa. State College.
KENT, Clarence H. ('27), Assoc. Prof. M. E., Pa. State College; *for mail,* Twin Oaks.
MACKENZIE, Kenneth D. (J'35), Graduate Student, Engrg. Exper. Sta., Pa. State College.
PETERS, Wm. H. (J'31), M. E. Lab., Pa. State College.
SACKETT, Robt. L. ('15; F'36), Manager, '32-'35; Vice-President, '35-'37; Dean Engrg., Pa. State College.
SCHWEITZER, Paul H. ('33), Prof. Engrg. Research, Pa. State College.
SIGWORTH, Robt. Y. ('20; '26), Supt. Utilities, Pa. State College; *for mail,* 225 S. Atherton St.
STEWART, Fred'k C. ('25; '29; '35), Assoc. Prof. M. E., Pa. State College.
THOMPSON, Warren G. O. ('18; '26), Assoc. Prof. M. E., Pa. State College; *for mail,* 235 S. Gill St.
VANDEGRIFT, C. G. (J'30), Instr., Dept. M. E., Pa. State College, 200 Engrg. A.; *for mail,* 419 W. Fairmount Ave.
ZERBAN, Alex H. ('27; '36), Asst. Prof. M. E., Pa. State College; *for mail,* 536 E. Foster Ave.

STEELTON, Susquehanna Section

FENDRICH, C. Nelson (J'34), Bethlehem Steel Co., Steelton, Pa.; *for mail,* 17 Florence Pl., Prince Bay, S. I., N. Y.

SUNBURY, Central Pennsylvania Section

GEIGER, Walter C. (J'34), Asst. Engr., Armour Leather Co., Williamsport; *for mail,* 1051 E. Chestnut St., Sunbury.

SUSQUEHANNA, Anthracite-Lehigh Valley Section

SEKELY, Stephen (J'30), Spec. Pass. Car Apprentice, Coach Shop, Erie R. R. Co.; *for mail,* P. O. Box 185.

SWARTHMORE, Philadelphia Section

ASHTON, Randolph ('35; '35), Engr., Instructions & Reports, De Laval Steam Turbine Co., 900 N. Clinton Ave., Trenton, N. J.; *for mail,* 502 Cedar Lane, Swarthmore, Pa.
DICKSON, John ('32), Ch. Engr., Diesel Elec. Div., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 629 Strath Haven Ave., Swarthmore.
DOYLE, W. L. H. (J'16), Ch. Engr., Diesel Div., Baldwin-Southwark Corp., Philadelphia; *for mail,* 236 Benjamin West Ave., Swarthmore.
FAIRBANKS, Chas. M. (J'25), Engr., Charge Design, Gen. Elec. Co., 6901 Elmwood Ave., Philadelphia; *for mail,* 228 Garrett Ave., Swarthmore.
HANZLIK, Henry John ('03; '10), Steam Turbine Engrg. Dept., Westinghouse Elec. & Mfg. Co., Essington; *for mail,* 315 Cornell Ave., Swarthmore.
HOBBS, Wm. S. (J'28), 511 Yale Ave.
HOWARD, Cecil D. ('13; '14), M. E., Sun Shipbldg. & Dry Dock Co., Chester; *for mail,* 243 Ogden Ave., Swarthmore.
JACKSON, Arthur C. ('03; '10), 317 N. Chester Rd.
MOSELEY, Alex. W. ('00), 611 Elm Ave.
PHARO, Edw. W., Jr. (J'34), Service Man, Oil Burner Installation, Wm. S. Hobbs, 511 Yale Ave.; *for mail,* 612 Yale Ave.
RASMUSSEN, Harold V. ('23; '30), Div. Engr., Charge Turbine Devel., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* Rutgers Ave. & Chester Rd., Swarthmore.
SMITH, Ronald B. (J'30), Engr., Westinghouse Elec. & Mfg. Co., Lester Branch P. O., Philadelphia; *for mail,* 609 Elm Ave., Swarthmore.
THATCHER, Chas. G. ('19; '25), Assoc. Prof. M. E., Swarthmore College; *for mail,* 613 Ogden Ave.
THOM, Geo. B. (J'34), Asst. Prof. M. E., Swarthmore College.

SWISSVALE, Pittsburgh Section

BONE, Herbert L. ('23; '35), Gen. M. E., Union Switch & Signal Co.
BUENTING, Otto W. ('14), V. P., Charge Mfg., Union Switch & Signal Co.
CLAUSEN, Harold C. ('28), M. E., Union Switch & Signal Co., Swissvale; *for mail,* R. D. 1, Wilkinsburg.
JEHEBER, Rodrigue A. ('27; '35), Asst. Ch. Engr., Charge Engrg., Wilson-Snyder Mfg. Corp., 1st & Talbot Sts., Braddock; *for mail,* 7921 Graff Ave., Swissvale.
LIVINGSTON, J. Warner (J'25), Engr., Union Switch & Signal Co., Swissvale; *for mail,* 7130 MacPherson Blvd., Pittsburgh.
PLUMMER, Wade S. (J'36), Spec. Apprentice, St. Clair St. Eng. House, Pa. R. R., Columbus, Ohio; *for mail,* 1316 Milton Ave., Swissvale, Pa.
SPEER, J. Robert (J'34), 237 Whipple St.

TERRE HILL, Susquehanna Section

WANNER, Ralph (J'35).

UPPER DARBY, Philadelphia Section

BROWN, Albert K. ('21; '25; '35), Estimator, Riggs Distler & Co., 1518 Walnut St., Philadelphia; *for mail,* 39 Kent Rd., Upper Darby.
CONNER, John L. ('27), Asst. Gen. Supt., Charge Sta. Opera., Philadelphia Elec. Co., 900 Sansom St., Philadelphia; *for mail,* 241 Strathmore Rd., Brookline, Upper Darby.
CORL, Harry E. ('22; '35), Cons. Engr., 207 S. 24th St., Philadelphia; *for mail,* 130 Overhill Rd., Upper Darby.
DONNELLY, M. A., (J'35), 500 Manoa Rd., Brookline.
FLOWER, Arthur D. ('24), Sec. D, Shirley Court Apts.
HOEHLER, Geo. W. ('30; '35), Instr. Mech. Drawing, Upper Darby Sr. High Sch., Lansdowne Ave., Upper Darby; *for mail,* 104 Lyle Ave., W. Manayunk, Philadelphia.
HOFFNER, Chas. M. (J'35), M. E., Charge Tools, Wm. Sellers & Co., Inc., 1600 Hamilton, Philadelphia; *for mail,* 2515 Hirst Terrace, Upper Darby.
HOGG, John W. ('18; '26), Constr. & Repairs, Grasselli Chem. Dept., E. I. du Pont de Nemours & Co., 3500 Grays Ferry Rd., Philadelphia; *for mail,* 28 Meadowbrook Ave., Llanerch, Upper Darby.
MILLIGAN, G. H., Jr. (J'36), 62 Harvard Rd., Brookline.

VANDERGRIFT, Pittsburgh Section

BODWELL, Howard L. ('07), Mgr., Vandergrift Wks., Am. Sheet & Tin Plate Co.
SMELTZER, Alton B. (J'31), Jr. Engr., Exec. Training, Am. Sheet & Tin Plate Co.; *for mail,* 220 Emerson St.

VILLANOVA, Philadelphia Section

BARBER, Wm. J. ('25; '32; '35), Assoc. Prof. M. E., Villanova College; *for mail*, Box 363.
LONGMAID, Sydney E. (J'28), Prod. Mgr., M. E., Charge Maint., Esterbrook Pen Co., Cooper St., Camden, N. J.; *home address*, Aldwyn Lane, Villanova, Pa.
MOREHOUSE, J. Stanley ('21; '25; '35), Prof. M. E., Head of Dept., Villanova College, Villanova; *for mail*, 209 S. Madison Ave., Upper Darby.
TAYLOR, H. Birchard ('10; '13), Vice-President, '24-'25; Spring Mill & Conshohocken Rds., Villanova; *for mail*, Bryn Mawr.

WALLINGFORD, Philadelphia Section

FULWEILER, Walter H. ('28).

WARREN, Erie Section

DOHRMANN, Henry Chas. (J'36), Design Engr., Buell Engrg. Div., Struthers-Wells Co.; *for mail*, 6—4th St.
EMHARDT, Fred W. (J'30), Design Engr., Struthers-Wells Co.; *for mail*, 20—4th Ave.
GREAVES, W. A. ('23), Engr., Charge Spec. Design, Struthers-Wells Co.; *for mail*, 208 W. 5th Ave.
McCONNELL, Chas. W. (J'35), Ch. Chem. Engr., Conewango Refining Co.; *for mail*, 11 Jefferson Ave.

WAYNE, Philadelphia Section

BROWNE, Frank A. ('13), 215 S. Aberdeen Ave.
DALE, David W. (J'35), 421 Woodland Ave.
GRAY, John W. ('95; '26), Retired; 226 Windermere Ave.

WAYNESBORO, Central Pennsylvania Section

LANDIS, Mark H. ('13; '35), Pres. & Gen. Mgr., Landis Engrg. & Mfg. Co., 225 Ringgold St.; *for mail*, 228 Philadelphia Ave.
MARTIN, Lemuel H. (J'26), P. O. Box 255.
NEWMAN, Saml. F. ('19), V. P., Charge Mfg., Landis Mch. Co.; *for mail*, Clayton Ave.
REICHENBACH, Hugo (J'32), Engr., Frick Co., Inc.; *for mail*, Wayne Bldg.
ROJAHN, J. Stetler (J'36), R. 1.

WESLEYVILLE, Erie Section

GILBERT, Lowell B. (J'36).

WEST CHESTER, Philadelphia Section

HETZEL, Frederic V. ('17), Cons. Engr. & Author, 103 Dean St.

WEST HOMESTEAD, Pittsburgh Section

BAUDRY, Paul ('29), Designer, Mesta Mch. Co., W. Homestead; *for mail*, 8009 Lloyd Ave., Swissvale.

WILKES-BARRE, Anthracite-Lehigh Valley Section

NICHOLSON, Saml. T. ('04), Pres., Gen. Mgr., Vulcan Iron Wks.
SMITH, Edw. Jos. ('04), Pres., Exeter Mch. Wks., Inc., Coal Exchange Bldg.
WOOD, Stanley V. ('13; '35), 448 S. Franklin St.

WILKINSBURG, Pittsburgh Section

FISKE, Richard T. (J'36), Sales Student, Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail*, 910 North Ave., Wilkinsburg.
HANSON, Harold F. (J'28), Design Engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *for mail*, 1016 Wallace Ave., Wilkinsburg.
MATTERN, John F. ('22), Gen. Supt., (Plant) Elliott Co., Jeannette; *for mail*, 715 North Ave., Wilkinsburg.
McCARTY, Roy A. ('36), Mgr., Generator Div., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; *home address*, 607 Whitney Ave., Wilkinsburg.
NADAI, A. ('29), Cons. Engr., Research Labs., Westinghouse Elec. & Mfg. Co., E. Pittsburgh; also, Research Prof., Univ. of Pittsburgh; *home address*, 113 Cherry Valley Rd., Wilkinsburg.
NISBET, Geo. P. (J'31), Draftsman, Designer, Jones & Laughlin Steel Corp., 27th & Carson Sts., Pittsburgh; *for mail*, 315 Newport Rd., Forest Hills, Wilkinsburg.
REDMOND, John H. (J'33), Westinghouse Club, 501 Pennwood Ave.
SAYLES, Bertram J. (A'31), Pres., Calorizing Co., Box 157.

WILLIAMSPORT, Central Pennsylvania Section

BRIGGS, Elmer J., Jr. (J'35), Asst. Exper. Engr., Aviation Mfg. Corp., Oliver St.; *for mail*, 721 W. 3rd St.
BROWN, Chas. G., Jr. ('25; '29), Foreman, Shop & Engine House, Pa. R. R., Park Sta.; *for mail*, 1125 Walnut St.
KIESEL, John S. ('27), Wks. Mgr., Charge Plant & Engrg., Darling Valve & Mfg. Co.
MILLER, J. Melvin (J'35), Jr. Analytical Engr., Lycoming Div., Aviation Mfg. Corp., High St.; *for mail*, 2216 W. 4th St.
OEHRLI, John W. (J'24), 1025½ Rural Ave.
ROZENBERG, Henry W. ('26; '35), Ch. Engr., J. K. Mosser Leather Corp., 500 Arch St.
SHEPHERD, Wm. G. ('90; '04), Gen. Mgr., Shepherd Engrg. Co.; *for mail*, 1421 Sherman Rd.
STABER, Geo. Ingraham (J'29), Spencer Heater Co.
WALLIN, Jos. W. ('31; '33; '35), Designer, E. Keeler Co.; *for mail*, 729 Lincoln Ave.

WILLOW GROVE, Philadelphia Section

PITCAIRN, Harold F. (A'30), Pres., Pitcairn Autogiro Co.

WILMERDING, Pittsburgh Section

AINSWORTH, John R. (J'28), Apprentice Engr., Westinghouse Air Brake Co.; *for mail*, 353 Marguerite Ave.
COOK, Earle S. ('25; '29), Asst. Research Engr., Westinghouse Air Brake Co.
COTTER, Geo. L. (J'24), Dist. Engr., Westinghouse Air Brake Co., Wilmerding; *for mail*, 256 Cascade Rd., Edgewood Acres, Wilkinsburg.
McCUNE, Jos. C. ('16; '27), Asst. Dir. Engrg., Westinghouse Air Brake Co., Wilmerding; *for mail*, 420 Locust St., Swissvale.
NASH, Richard L. (J'34), Test Engr., Charge Air Compressor Devel. Tests, Westinghouse Air Brake Co., Wilmerding; *for mail*, 217 Pennwood Ave., Wilkinsburg.
STEWART, Carlton D. ('28), Ch. Engr., Westinghouse Air Brake Co.
WELTON, Alvin A. (J'36), Test Div., Engrg. Dept., Westinghouse Air Brake Co.; *for mail*, 353 Marguerite Ave.

WYNCOTE, Philadelphia Section

FISCHER, Kermit M. (J'30), Engr., Charge Flow Meter Dept., Schutte & Koerting Co., 12th & Thompson Sts., Philadelphia; *for mail*, Royal & Keswick Ave., Wyncote.
WILLIAMS, Maurice W. ('23; '28; '35), Field Engr., Mfrs. Mutual Fire Ins. Co., 52 Vanderbilt Ave., New York, N. Y.; *for mail*, 114 Wavery Rd., Wyncote, Pa.

WYOMISSING, Anthracite-Lehigh Valley Section

HARPER, Arthur C. ('20), Pres., Wyomissing Poly. Inst.
MEYER, Christian F. ('23), Ch. of Engrg. Dept., Textile Mch. Wks., Box 940, Reading; *for mail*, 1408 Garfield Ave., Wyomissing.
RAHM, Robt. C. ('14), Design Engr. & Treas., Berks Engrg. Co., 6th Ave. & Chestnut St., Reading; *home address*, 1125 Belmont Ave., Wyomissing.

YEADON, Philadelphia Section

LAIMING, Harry J. (J'34), Drafting, Spec. Equip., RCA Victor Div., RCA Mfg. Co., Inc., Camden, N. J.; *for mail*, 429 Orchard Ave., Yeadon, Pa.

YORK, Susquehanna Section

AUGHENBAUGH, Elmer E. (J'36), Engr. Training for Prod. Mgmt., S. Morgan Smith Co., Hartley & Lincoln Sts.; *for mail*, 141 N. Newberry St.
BELINE, Walter E. (J'30), Equip. Devel. Dept., York Ice Mchy. Corp.
BISCHOFF, Robt. (J'30), Asst. Mgr., Ch. Engr. Charge Design, Valve Div., S. Morgan Smith Co., Hartley & Lincoln Sts.; *for mail*, 311 N. Penn St.
BOWLUS, Benj. H. ('29), Devel. Engr., Am. Insulator Corp., New Freedom; *for mail*, 26 N. Vernon St., York.
BREDA, Thoralf Kristian ('29; '31; '35), Designing Engr., S. Morgan Smith Co., N. Hartley St.; *for mail*, 630 Madison Ave.
CAMPBELL, Gordon ('91; '14), Box 293.
CLARK, Ellery D. (J'33), Mch. Designer, York Ice Mchy. Corp., Roosevelt Ave.; *for mail*, Yorkco Club.
DORBANDT, Fred C. ('32; '35), Engr., Engrg. Dept., Hercules Powder Co., Wilmington, Del.; *for mail*, 1510—3rd Ave., York, Pa.
EARLL, Chas. I. ('92), 441 Lincoln Ave.
FARQUHAR, Francis ('07), Pres., A. B. Farquhar Co., Ltd.
FISCH, Jacob ('30; '36), Asst. Ch. Draftsman, S. Morgan Smith Co.
FISHER, Wm. J. ('19; '33), V. P. & Gen. Mgr., A. B. Farquhar Co., Ltd., 142 N. Duke St.; *for mail*, 487 Madison Ave.
JONES, Mack M. (J'34), Air Conditioning Design, York Ice Mchy. Corp., Roosevelt Ave.; *for mail*, 749 Madison Ave.
MARSTON, Chas. D. (J'32), Student Engr., York Ice Mchy. Corp.; *for mail*, 660 W. King St.
MARTIN, Henry B. ('27; '36), Asst. Works Mgr., York Ice Mchy. Corp.; *for mail*, Box 6.
McCORMACK, Daniel Jas. ('18), Sales Mgr., S. Morgan Smith Co.
MORSE, Louis S., Sr. ('32), Exec. Engr., York Ice Mchy. Corp.
ROSS, Harold J. M. ('26; '34; '35), Hyd. Engr., S. Morgan Smith Co., Hartley & Lincoln Sts.; *for mail*, 259 Roosevelt Ave.
RUSSELL, R. J. (J'28), Sales Engr., Hardinge Co., Inc.
SILBERGER, Marvin E. ('32), Engr. Charge Design & Devel., Wright Mfg. Div., Am. Chain Co., Inc., Charles & Princess Sts.; *for mail*, 1508—2nd Ave.
SMITH, Beauchamp E. (J'24), Secy., S. Morgan Smith Co.
SMITH, Gerard L. (J'36), Indus. Engr., Mfr. Cost Control Dept., York Ice Mchy. Corp.; *for mail*, Yorkco Club, 611 Company St.
SPANGLER, John I. ('21; '29; '35), V. P., Charge Prod., Read Mchy. Co., Inc.; *for mail*, 292 Jefferson Ave.
TURNER, Wm. W., Jr. (J'36), Yorkco Club, 611 Company St.
WEBER, Oscar E. ('29; '35), Ch. Draftsman, Charge Design, S. Morgan Smith Co., Lincoln & Hartley Sts.; *for mail*, 308 Kurtz Ave.
WILLIAMS, Llewellyn ('07), Engr.-in-Chief, York Ice Mchy. Corp., York, Pa.; *for mail*, 8802—193rd St., Hollis, L. I., N. Y.
ZIEBER, W. E. ('35), Asst. Ch. Engr., York Ice Mchy. Corp.

YOUNGWOOD, Pittsburgh Section

ROBERTSHAW, C. W. (J'29), V. P. & M. Engr. Test., Robertshaw Thermostat Co., Youngwood; *for mail*, 524 Harrison Ave., Greensburg.

ZELIENOPLE, Pittsburgh Section

ROBINSON, Jas. R. ('05), Pres., Robinson Ventilating Co.

ZIONSVILLE, Anthracite-Lehigh Valley Section

SEEM, Chas. B. ('11; '19; '24), Box 2, Route 1.

PHILIPPINE ISLANDS

CEBU, Cebu

BORROMEO, Canuto O. ('16; '26), Mgr., Cebu Branch, Philippine Engrg. Corp., P. O. Box 308.
TANCO, Arturo V. ('35), Cons. Engr., Cebu Portland Cement Co., Naga.

MAMBAJAO

DOLUMBAL, Teodulo A. (J'32), Mambajao, Oriental Misamis.

MANAPLA, Occidental Negros

CHESTER, Harold Dean (J'32), Asst. Supt., Mfg., North Negros Sugar Co.

MANILA, Luzon

AMES, Aubrey P. ('25; '30), Lub. & Fuel Oil Mgr., Stand.-Vacuum Oil Co.
BLAISDELL, Benj. H. ('09), Supt., Power Plants, Manila Elec. Co.
CARLZ, Jos. F. ('21; '35), Ch. Engr., Stand.-Vacuum Oil Co.
EATON, Leon S. ('22), Prof., Head. Mech. Dept., College of Engrg., Univ. of Philippines; *for mail*, 1376 Gral Luna.
FLORO, Martiniana ('32), Floro Bros., Paterno Bldg.
GARCIA, Pedro (J'36), 619 Colorado St.
IMPERIAL, F. Fabiano (J'35), Asst. Engr., Charge Design, Natl. Devel. Co., 732 Evangelista.
KENNEDY, J. E. ('13), Earnshaws Docks & Honolulu Iron Wks., 75 B. C. Shameen, Canton, China; *for mail*, P. O. Box 1640, Manila, P. I.
PARKER, Ray L. ('22; '29), Engrg. Equip. & Supply, 180 Calle David.
REICH, Henry Leo ('23; '32), Mgr., Elec. & Mchy. Depts., Manila Mchy. & Supply Co., 675 Dasmarinas; *for mail*, 1227 M. H. del Pilar.
SEVILLA, Gregorio J. (J'30), Head, Ironworking Dept., Philippine Sch. of Arts & Trades, Manila; *for mail*, 41 Sta. Escolastica St., Pasay, Rizal.

SAN CARLOS, Occidental Negros

HOGAN, Curt L. ('21; '35), Mgr., San Carlos Milling Co.

PUERTO RICO

CANOVANAS, Loiza

COCHRAN, Alex R. ('22; '35), V. P., Gen. Mgr., Loiza Sugar Co., Central Canovanas.

CENTRAL AGUIRRE, Salinas

HILL, Albert J. (J'32), Asst. M. E., Opera., Maint. & Constr., Central Aguirre Sugar Co.
PERCY, Jas. P. ('25; '30), M. E., Ch. Engr., Opera., Maint. & Constr., Central Aguirre Sugar Co.
WATERBURY, Lewis C. ('24), Mgr., Ponce & Guayama R. R. Co.

CENTRAL EL EJEMPLO, Humacao

HANSEN, Holger H. ('26), Administrator, Gen. Supt. & Ch. Engr., Cia Azucarera El Ejemplo; *for mail,* Central El Ejemplo.

CENTRAL MERCEDITA, Ponce

CINTRON, Guillermo E. (J'27).
THOMPSON, Sidney ('26; '30), Ch. Engr., Porto Rico Am. Sugar Refinery, Inc., Central Mercedita; *for mail,* Box 1788, Ponce.
WIRSHING, Armando O. (J'34).

FAJARDO, Fajardo

GROSSENBACHER, Ernest ('21; '35), Ch. Engr., Fajardo Sugar Co., Central Fajardo.

HUMACAO, Humacao

ROIG, J. Adalberto ('24; '30; '35), V. P., Yabucoa Sugar Co.; *for mail,* Humacao.

MAYAGUEZ, Mayaguez

BRAVO, Oscar F. (A'29), Pres., Gen. Mgr., Mayaguez Sugar Co., Inc., P. O. Box 188.
GIL, Ramón I. ('26; '33; '35), Asst. Prof. & Asst. Supt. Bldgs. & Grounds, Univ. of P. R.; *for mail,* 114 Meñdez Vigo.
RAMIREZ, Efrain (J'29), Box 627, 6 Salud St.

PONCE, Ponce

ANTONSANTI, Louis ('16; '35), Engr., Contr., P. O. Box 69.
BREWER, Juan O. Cepero (J'35), Jr. M. E., Sucesion Serralles; *for mail,* 5 Ferrocarril St.
JUNGHANS, Edw. K. ('08), Retired; P. O. Box 781.
RAMOS, Luis Cortes (J'34), Sol E. No. 20.

SAN JUAN, San Juan

BEHR, F. J. ('14), Col., Coast Artillery Corps, U. S. A.; Ch., Puerto Rican Hurricane Relief, Loan Section; *for mail,* P. O. Box 289.
CARMOEGA, Enrique R. ('27), M. E., M. P. Dept., Am. R. R. Co. of P. R., P. O. Box 359.
COPP, Earle M. ('28), Managing Engr., Petree & Dorr, Engrs., Inc., P. O. Box 516.
RAMIREZ, Abelardo E. (J'36), 22 Isabel Segunda St.

SANTURCE, San Juan

TORRES, Angel ('25; '33; '35), 8 Robles Ave.

RHODE ISLAND

AUBURN, Providence Section

BROWN, Walter H., Jr. (J'33), 206 Pontiac Ave.

BRISTOL, Providence Section

HERRESHOFF, Nathanael G. (H'21), Retired; 6 Walley St.

CENTRAL FALLS, Providence Section

BUTTERFIELD, Alvin W. (J'34), 31 Notre Dame St.
SUGERMAN, David L. (J'35), 795 Broad St.

CRANSTON, Providence Section

BENNS, Chas. P. ('98), Retired; 33 Bowen St., Edgewood.
BULLARD, John E. (A'13), Tech. & Business Writer, 83 Colonial Ave.
MERRIAM, Paul A. ('19; '28), Mfrs. Rep., Engrg. & Textile Finishing Equip., 11 Berwick Lane, Edgewood.

GREENWOOD, Providence Section

NORTHUP, Wm. C. (J'33), 56 Myrtle Ave.
WATELET, Paul Louis (J'34), Telemetering Testing, Builders Iron Fdy., Kinsley Ave., Providence; *for mail,* 240 Post Rd., Greenwood.

KINGSTON, Providence Section

BILLMYER, Carroll D. ('16; '26), Asst. Prof. Engrg., R. I. State College.
CARPENTER, Edw. L. ('22; '30), Prof. M. E., Charge Opera. & Maint., R. I. State College.
NICHOLS, G. B. ('15).
PERRY, Millard F. (J'36), Draftsman, Brown & Sharpe Mfg. Co., Promenade St., Providence; *for mail,* P. O. Box 117, Kingston.
RANDOLPH, Jas. R. ('19; '23; '35).
WALES, Royal L. ('23), Dean Engrg., R. I. State College; *for mail,* Campus Ave.

NEWPORT, Providence Section

CREPEAULT, Henry F. (J'26), Engrg. Draftsman, Tool & Gage Designer, U. S. Naval Torpedo Sta.; *for mail,* Coggeshall Ave.
GARNEAU, Leo A. (J'30), Engrg. Draftsman, Design Div., U. S. Naval Torpedo Sta.; *for mail,* Army & Navy Y. M. C. A.
LINSLEY, L. N. ('25), Comdr., U. S. N., Naval War College.
McCONNELL, Jas. W. ('18), M. M., U. S. Naval Torpedo Sta.; *for mail,* 350 Broadway.
STRATTON, Julian A. ('21), Assoc. Engr., Pub. Wks. Dept., Naval Training Sta.; *for mail,* 22 Bliss Rd.
WHITAKER, R. J. (J'30), Sr. Inspr. Engrg. Matls., U. S. Naval Torpedo Sta.; *for mail,* 13 Pell St.

PAWTUCKET, Providence Section

BULLOCK, Edwin R. ('90; '04), 38 Brook St.
FISHER, Howard C. ('12; '19; '20), Pres., Treas., Cent. Engrg. & Constr. Co., 210 Main St.
GIBLING, Harold F. ('30; '35), Chief Engr., Woonsocket Rayon Co., Woonsocket; *for mail,* 26 Beech St., Pawtucket.
HACKING, Chester ('28), Supt. & M. E., Wm. H. Haskell Mfg. Co., 24 Commerce St., Pawtucket; *for mail,* 68 Lorraine Ave., Providence.
McDEVITT, John N. ('17; '26; '35), Mgr., Treas., Lincoln Mch. Co., 260 Esten Ave., Pawtucket; *for mail,* 65 Harwich Rd., Providence.

PHILLIPSDALE, Providence Section

JOHNSON, Kenneth S. ('20; '26), Mech. Supt., Glenlyon Print Wks., Phillipsdale; *for mail,* 73 Read Ave., Saylesville.
MACKENZIE, Morell (J'12), Mgr., Glenlyon Print Wks., Sayles Finishing Plants, Plant C, Phillipsdale; *for mail,* 104 Irving Ave., Providence.

PONTIAC, Providence Section

CRAIG, Jas. G. (J'26), Engr., Charge Plant, Pontiac Finishing Plant.

PROVIDENCE, Providence Section

ALDRICH, John G. ('01), Pres., New Eng. Butt Co., 304 Pearl St.
BAINTON, Arthur H. ('25), Wks. Mgr., Brown & Sharpe Mfg. Co.
BARNINGHAM, Chas. Strawson ('30), Sales Mgr., New Eng. Butt Co., 304 Pearl St., Providence; *for mail,* 83 Bluff Ave., Edgewood, Cranston.
BEEDE, E. Bennett (J'35), M. E., Franklin Rayon Corp., 86 Crory St.
BENNETT, Arthur F. ('21; '35), Mch. Designer, Brown & Sharpe Mfg. Co., Promenade St., Providence; *for mail,* 360 Washington Rd., W. Barrington.
BERARD, Saml. J. ('19), Assoc. Prof. Engrg. Drawing, Brown Univ.
BLANDING, Robt. L. ('13), V. P., Charge Engrg., Mfg. & Factory Sales, Taco Heaters, Inc., 123 South St., Providence, R. I. & 342 Madison Ave., New York, N. Y.; *for mail,* 1385 Smith St., Providence.
BLISS, Zenas R. ('23; '30; '33), Asst. Prof. Applied Mechs., Brown Univ.
BLOSS, Leonard C. M. ('21; '27; '30), Nicholson File Co.; *for mail,* 205 Governor St.
BOROVOY, Saml. ('30), Engr., Charge Design, Universal Winding Co.
BRADLEY, Earl H. (J'29), Engr., Exper. Dept., Brown & Sharpe Mfg. Co., Providence; *for mail,* P. O. Box 105, E. Providence.
BROWN, Wendell S. ('16; '18; '22), Ch. Engr., F. P. Sheldon & Son, 1038 Hospital Trust Bldg.
BUKER, Henry ('07), V. P., Brown & Sharpe Mfg. Co., P. O. Box 1385.
BUTTOLPH, Benj. G. ('05), V. P., Engr., Mfrs. Mutual Fire Ins. Co., P. O. Box 1485, 815 Grosvenor Bldg.
CADY, Geo. H. ('29; '35), Plant Engr., U. S. Finishing Co., 389 Charles St.; *for mail,* 73 Roslyn Ave.
CALDER, Augustus W., Jr. (J'32), Asst. Mgr., New Eng. Butt Co., 304 Pearl St.; *for mail,* 184 Angell St.
CHAFEE, John S. ('26; '35), Asst. Secy., Sales Dept., Brown & Sharpe Mfg. Co., Promenade St.
CHAPMAN, Kenneth B. ('33), 32 President Ave.
CHICK, Alton C. ('21; '34), Engr., Fire Prevention Engrg., Mfrs. Mutual Fire Ins. Co., 815 Grosvenor Bldg.
CHILDS, E. Wallace, Jr. (J'33), 204 Burgess Ave., E. Providence.
CHILDS, Henry B. (J'35), 204 Burgess Ave., E. Providence.
COLEMAN, John B. ('21), Ch. Engr., Charge Fire Protection Engrg., Grinnell Co., Inc., 260 W. Exchange St.
COLLIANDER, C. Torsten (J'35), 158—8th St.
CONGDON, John E. ('22), Cons. Engr., 26 President Ave.
CONNOLLY, Jas. H. ('13; '13), Treas., Gen. Mgr., Stand. Mchy. Co.; *for mail,* 164 Rochambeau Ave.
CUTTING, Fred'k S. ('34), Deputy Pub. Serv. Engr., City of Providence; *for mail,* 98 Carolina Ave.
DART, Wm. C. (A'07), Pres., R. I. Tool Co., P. O. Box 1516.
DAVIS, Francis P. ('13; '21; '35), Pres., Davis Drive Yourself Co., Inc.; *for mail,* 236 Meeting St.
DAY, Edwin Terry ('31), New Eng. Serv. Engr., Diamond Power Specialty Corp., Detroit, Mich.; *for mail,* 149—8th St., Providence, R. I.
DAY, Richmond A. (J'31), Foreman in Charge, Lastex Covering, Natl. India Rubber Co., 355 Valley St., Providence; *for mail,* 204 Narragansett St., Edgewood.
DeWOLF, Paul C. (A'15), V. P., Asst. Treas., Brown & Sharpe Mfg. Co., Promenade St.
DICKERMAN, Albert C. ('11), M. E., 45 Nisbet St.
DOMAIGE, Gommaire L. J. (J'32), Engr., Builders Iron Fdy., 9 Codding St.; *for mail,* 29 Wildwood Ave.
DREWETT, Wm. A. ('88), Pres., Gen. Mgr., Providence Engrg. Wks., Inc., 521 S. Main St.
DuVILLARD, Henry A. ('84), M. E., 173 George St., East Side Sta.
ELDERT, John D. (J'31), Asst. Mgr., M. E., Mch. Parts Corp., 271 Washington St.
ENGLUND, John E. (J'36), M. E., Design, Brown & Sharpe Mfg. Co., Providence; *for mail,* 219 Fair St., Edgewood.
ESTES, Wm. W. ('91; '04), Life Member; Research Engr., Gen. Fire Extinguisher Co., 260 W. Exchange St., Providence; *for mail,* 70 Mary Ave., E. Providence.
FALES, Henry H. ('13), 740 Grosvenor Bldg.
FILES, Wm. R. ('21), Pres., Treas., Files Engrg. Co., Inc., 710 Eddy St.
FITZSIMMONS, Saml. D. ('24), V. P., Commercial Mgr., So. Dist., Narragansett Elec. Co., 215 Union Trust Bldg.
FLETCHER, Ralph L. ('26), Engr., Providence Gas Co., 100 Weybosset St.
FOGG, Erlon S. ('21), U. S. Engr. Office.
FREEMAN, Clarke ('15; '22; '35), V. P., Charge Fire Prevention Engrg. & Underwriting, Mfrs. Mutual Fire Ins. Co., 10 Weybosset St.
FREEMAN, Evert W. ('30; '35), Plant Engr., Brown & Sharpe Mfg. Co.; *for mail,* 42 Freeman Pkwy.
FREEMAN, Fred'k C. ('11; '16), Pres., Providence Gas Co., 100 Weybosset St.
FREEMAN, Hovey T. ('19; '26; '35), Pres. & Treas., Mfrs. Mutual Fire Ins. Co., 10 Weybosset St.; *for mail,* 45 Hazard Ave.
GOMPERTZ, Walter (J'31), V. P. & Gen. Mgr., Mason Can Co., Dexter Rd., E. Providence.
GRAVES, Benj. P. ('23), Ch. Engr., Brown & Sharpe Mfg. Co.
HOLTON, Philip J., Jr. ('29; '35), Supt., Providence Water Wks., City Hall.
HORAN, Norman E. (J'29), Time Study Engr., Ostby & Barton Co., 118 Richmond St.; *for mail,* 24 Adelaide Ave.
HOWE, Everett W. (J'27), Power Engr., Natl. India Rubber Co., Eagle St.
HUXFORD, Geo. T. ('30), Ch. Engr., Builders Iron Fdy. & Diamond Mch. Co., 9 Codding St.
JONES, Morris Wm. (J'32), Engr., Gulf Oil Corp., Barrington Pkwy., Providence; *for mail,* 19 Paine Ave., Auburn.
KEATING, Arthur E. ('19; '23; '35), Wks. Mgr., Bronze & Plastics Divs., Gorham Mfg. Co., Providence; *for mail,* 1463 Narragansett Blvd., Cranston.
KENERSON, Wm. H. ('04; F'36), Vice-President, '22-'24; Chmn. Div. Engrg., Prof. M. E., Brown Univ.
KENNEDY, Wm. A. ('08; '14), Supvr. Products, Grinnell Co., Inc., 260 W. Exchange St.; *for mail,* 31 Forest St.
KISTLER, Paul N. ('24; '30), Assoc. Prof. M. E., Brown Univ.
KNIGHT, Earl R. ('17; '26; '35), Sales Engr., Manchester & Hudson Co., 573 Eddy St.; *for mail,* 108 Peace St.
LEWIS, Herbert B. ('25; '28), Charge Exper. Dept., Brown & Sharpe Mfg. Co.; *for mail,* 122 Irving Ave.
LOEPSINGER, Albert J. ('08; '13), M. E., Charge Research, Gen. Fire Extinguisher Co.
LYON, Jas. F. (A'20), Sales Engr., Brown & Sharpe Mfg. Co.
MacLEOD, Norman D. ('34), Pres., Gen. Mgr., Abrasive Mch. Tool Co., Dexter Rd., E. Providence.
MATHEWSON, M. I. ('22), M. E., Charge Grinding Mch. Design, Brown & Sharpe Mfg. Co.; *for mail,* 113 Williams St.

MAYO, Edmund Cooper ('16), Pres., Gen. Mgr., Gorham Mfg. Co.
McELROY, Peter S. ('21; '35), 108 Eaton St.
McGINN, Leo Francis ('31; '35), Sales Engr., Grinnell Co., Inc., 260 W. Exchange St., Providence; *for mail,* 38 E. Main St., W. Warwick.
MEEHAN, Jas. ('33; '35), Sales, Mch. Tools, Brown & Sharpe Mfg. Co.
MEYER, A. Wm. ('25; '32; '35), Indus. Dept., Brown & Sharpe Mfg. Co., Providence; *for mail,* 382 Main St., Warren.
MOREY, Chester T. ('28), Supt., R. I. Tool Co., 148 W. River St.
MOSES, Fred'k T. ('16; '23), V. P. & Engr., Firemans Mutual Ins. Co., 10 Weybossett St.; 560 Lloyd Ave.
MOULDER, Albert W. ('21), V. P., Grinnell Co., Inc., 260 W. Exchange St.
ODE, Randolph T. ('01; '08), Pres., Secy., Providence Lithograph Co., 353 Prairie Ave.
O'NEILL, Jas. L. ('28; '35), 302 Academy Ave.
PEARCE, Richard Wm. (J'36), 36 Huxley Ave.
PHILLIPS, Herbert Saml. (J'34), 369 Hope St.
POHLE, Hans A. (J'30), M. E., Providence Gas Co., 477 Dexter St.; *for mail,* 10 Vineyard St.
RICHARDSON, Chas. G. ('11), Mgr., Municipal Sales, Builders Iron Fdy.; *for mail,* 185 Taber Ave.
RUGH, John M. ('33), M. E., Geneva Mill, 1117 Douglas Ave.
SATTLER, Fritz C., Jr. (J'35), Apprentice, Thurston Mfg. Co., 45 Borden St., Providence, R. I.; *for mail,* 87 Mason St., Rehoboth, Mass.
SCHAFER, Theo. W. D. (J'31), Research Engr., Atlantic Mills, 120 Manton Ave.; *for mail,* 625 Public St.
SCOTT, Roger M. ('32; '36), Ch. Engr., New Eng. Butt Co., 304 Pearl St.; *for mail,* 242 Cypress St.
SHAAL, Lester F. (J'29), Research Engr., Atlantic Refining Co., Hospital Trust Bldg., Providence; *for mail,* 39 Norwood Ave., Edgewood.
SHARPE, Henry D. (A'01), Treas., Brown & Sharpe Mfg. Co., Box 1385.
SHELDON, Arthur N. ('16), F. P. Sheldon & Son, 1038 Hospital Trust Bldg.
SIMEON, Chas. J. ('13), Gen. Mgr., Ostby & Bayton Co., 118 Richmond St.
SIZER, Harold S. (J'34), Design Analyst, Brown & Sharpe Mfg. Co., Providence; *for mail,* 154 Beechwood Ave., Pawtucket.
SPENCE, Lewis D. ('27), Charge Tool Designing, Brown & Sharpe Mfg. Co.; *for mail,* 706 Fruit Hill Ave.
SPICER, Geo. Thurston, Jr. (J'35), Clerk, Hope Webbing Co.; *for mail,* 306 Olney St.
TABER, Leonard S. (J'33), Jr. Engr., Dept. of Distribution, Narragansett Elec. Light Co., Providence; *for mail,* 108 Norfolk St., Cranston.
VAN BODEGOM, John ('27), Drafting Engr., U. S. Rubber Products, Inc., Valley & Eagle Sts.; *for mail,* 430 River Ave.
VAULE, Sven A. (J'23), Charge Wage Incentive Dept., Brown & Sharpe Mfg. Co.
VIALL, Wm. A. (A'02), V. P., Brown & Sharpe Mfg. Co.; *for mail,* Box 1385.
WAGNER, Laurence E. ('28), Ch. Indus. Engr., Providence Gas Co., 100 Weybosset St., Providence; *for mail,* 37 Seaview Ave., Edgewood.
WATERMAN, Benj. F. ('21), Designer; Brown & Sharpe Mfg. Co.; *for mail,* 201 Vermont Ave.
WATERMAN, Raymond R. (J'35), Asst. Chemist, Prod., Koppers Co., Massasoit Ave., E. Providence, R. I.; *for mail,* R. D. 4, Box 283, Attleboro, Mass.
WEIMAR, Hans C. ('27; '35; '35), Mch. Designer, Grinding Mch. Div., Brown & Sharpe Mfg. Co.; *for mail,* 162 Lenox Ave.
WILEY, Russell C. (J'29), Asst. Engr., Power Sec., U. S. Rubber Products, Inc., 355 Valley St.
WILLIAMS, F. B. ('12; '14), Engr., Blackstone Mutual Fire Ins. Co., 10 Weybosset St., Providence; *for mail,* 115 Alfred Drowne Rd., W. Barrington.
WILLIAMS, J. Howard ('24), M. E., Gen. Fire Extinguisher Co., 260 W. Exchange St.
WILLIAMS, John Humphreys ('29; '35), Asst. Treas., Gen. Mgr., Marshall & Williams Mfg. Co., 46 Baker St.
WOOD, Jos. R. (J'35), 147 Lorimer Ave.
WOOLLEY, Ernest L. ('25), Pres., E. L. Woolley Co., 1511 Indus. Trust Bldg.

RUMFORD, Providence Section

SANDAGER, Wm., Jr. (J'35), 240 Pleasant St.
WILSON, Ellery L. ('31), Engrg. & Prod., Rumford Chem. Wks.

SAYLESVILLE, Providence Section

HERR, Geo. D. ('31; '35), Dept. Supt., Sayles Finishing Plants, Inc.; *for mail,* 14 Memorial Ave.
HOPE, Eric S. ('24; '34; '35), Dept. Supt., Sayles Finishing Plants, Inc.; *for mail,* 51 Kilburn Ave.
KILLAM, Horace G. ('27; '35), Asst. Mech. Supt., Sayles Finishing Plants, Inc.; *for mail,* 160 Chapel St.
RENO, Harold P. (J'07), Supt., Sayles Finishing Plants, Inc.; *for mail,* 159 Chapel St.

SLATERSVILLE, Providence Section

CHIFFELLE, Francis A. ('17), M. E., Charge Maint. & Design, Slatersville Div., Kendall Co.; *for mail,* P. O. Box 114.

WESTERLY, Norwich Section

ECKHARD, Wm. K. ('29), Engr., Charge Design, C. B. Cottrell & Sons Co.; *for mail,* 32 Chestnut St.
LUEHRS, Hans ('32), Designing Engr., C. B. Cottrell & Sons Co.; *for mail,* 24 Margin St.
PETROMAN, Onnie Mathias (J'32), Draftsman, C. B. Cottrell & Sons Co., Westerly, R. I.; *for mail,* R. F. D. 5, Norwich, Conn.

WOONSOCKET, Providence Section

BLACKALL, Fred'k S., Jr. ('29), Pres., Treas., Taft-Peirce Mfg. Co., 32 Mechanic Ave.
DURSIN, Henry, Jr. ('18; '25; '35), Asst. Mgr., Lafayette Worsted Co.
KENYON, Wm. Robt. (J'36), 488 Blackstone St.
MILLER, Chas. F. ('20), Pres., Gen. Mgr., Fairmount Fdy. Co., 2nd Ave., Woonsockett; *for mail,* 50 Moorland Ave., Providence.
MILLER, Paul V. ('30), Mgr., Small Tool Dept., Taft-Pierce Mfg. Co.
PARKER, Geo. C. ('18; '26; '35), Estimating Engr., Taft-Pierce Mfg. Co., 32 Mechanics St.; *for mail,* 94 Huntington Ave.

SOUTH CAROLINA

ANDERSON, Greenville Section

PRUITT, Ralph S. ('26; '32; '35), Mgr., Mech. Dept., C. M. Guest & Sons, Sharpe St.

CHARLESTON

GIBSON, Jas. E. ('96; '01; '10), Mgr. & Engr., Commissioners of Pub. Wks., Water Dept., 14 George St.
NATHAN, Henry H. (J'34), 43 Hasell St.

CLEMSON COLLEGE, Greenville Section

EARLE, Saml. B. ('05; '08; '14), Dean, Sch. of Engrg., Dir. Engrg. Exp. Sta., Clemson A. & M. College.
FERNOW, Bernhard E. ('28), Prof. M. E., Head M. E. Div., Clemson A. & M. College.
SAMS, Jas. H., Jr. (J'32), Asst. Prof., Clemson A. & M. College.
TOPPING, Chas. H. (J'30), 113 Parkway.

FROGMORE

ROWLAND, Richard H. ('33), Dathaw Island.

GEORGETOWN

RIIS, Erling ('27), So. Kraft Corp.

GREENVILLE, Greenville Section

BLACKWELDER, C. Davis ('19; '23; '34), Chem. & M. E., J. E. Sirrine & Co.; *for mail,* Box 1516.
CHAPMAN, Robt. H. ('19; '24; '27), Head Steam Engrg. Dept., J. E. Sirrine & Co.
FITZSIMONS, Wm. Huger, Jr. ('23; '35), Lubricating Sales, Stand. Oil Co. of N. J.
ILER, H. H. ('34), Plant Engr., Charge Maint., Union Bleachery, Box 598.
MAYO, Jas. Benj. ('18; '26), Secy., Treas., Greenville Country Club, P. O. Box 675; *for mail* Ottaray Hotel.
McPHERSON, John A. ('21), Ch. Engr., J. E. Sirrine & Co., 5 Main St.
MORGAN, Geo. R. ('34; '35), Owner, George R. Morgan, Sales Engr., W. Washington St.; *for mail,* P. O. Box 563.
SIRRINE, Jos. E. ('21), Sr. Partner & Exec. Head J. E. Sirrine & Co., 215 S. Main St.
STALL, Earle R. ('35), So. Rep., Textile Engr., Woodward-Baldwin & Co., of New York, N. Y.; *for mail,* P. O. Box 742, Greenville, S. C.
THOMPSON, F. M. (J'34), Box 835.

NEWBERRY, Greenville Section

ABRAMS, Cecil (J'33).

NORTH CHARLESTON

SHANNON, Jas. R. (J'29), Millwright Foreman, W. Va. Pulp & Paper Co.; *for mail,* Box 41.

SLATER, Greenville Section

TAYLOR, Wyllys H. ('28), V. P., Gen. Mgr. Slater Mfg. Co.

SPARTANBURG, Greenville Section

BINGHAM, Saml. A., Jr. (J'34), Cadet Engr., Taylor-Colquitt Co., Spartanburg, S. C.; *for mail,* Tryon, N. C.

WELLFORD

HILL, Frank (J'32), Tex. Co.; *for mail,* Wellford.

SOUTH DAKOTA

BROOKINGS

ALDRICH, Benj. M. ('27; '34; '35), Instr. M. E., S. D. State College.
STRATE, J. Taylor ('25; '33; '35), Prof. M. E., Head of Dept., S. D. State College.

LEAD

PULLEN, R. R. ('16; '20), M. E., Homestake Mining Co.
STAPLE, Sydney J. ('16; '35), M. M., Homestake Mining Co.; *for mail,* 110 McClellan St.

RAPID CITY

FOWDEN, Wm. ('13), Supt., State Cement Plant; *for mail,* P. O. Box 756.

SIOUX FALLS

MYHRE, Emmett B. (J'36), Maint. & Opera., Northern States Power Co.; *for mail,* 1317 W. 9th St.

VERMILLION

BROOKMAN, Harold E. ('25), Asst. Prof. Engrg., Univ. of S. D.; *for mail,* 107 Prospect St.
DAVIDSON, Morgan W. ('12), Prof., Applied Math., Univ. of S. D.; *for mail,* 222 Pine St.

TENNESSEE

ALCOA, Knoxville Section

BEERS, Geo. Huse (J'34), 413 Ramsey St.
FRANKUM, Jay L. (J'28), Alcoa Sheet Mill, U. S. Aluminum Co.; *for mail,* 419 Maury St.
HORNE, John ('25; '31; '35), Asst. Gen. Foreman, U. S. Aluminum Co., Alcoa; *for mail,* Box 55, Maryville.
KENNEDY, Wendell C. (J'23), Draftsman & Designer, U. S. Aluminum Co., Alcoa; *for mail,* 300 Cates St., Maryville.
LYLE, Edw. L. (J'28), Ch. Draftsman, U. S. Aluminum Co., Alcoa; *for mail,* 102 E. High St., Maryville.
STEPHENSON, Thos. I. ('20; '27; '35), Asst. Gen. Foreman, Unit 2, U. S. Aluminum Co., Alcoa; *for mail,* 209 Oak Park Ave., Maryville.

BRISTOL, Knoxville Section

JONES, Frank Alfred (J'35), Engr., Enterprise Wheel & Car Corp.; *for mail,* 331—5th St.

CHATTANOOGA, Chattanooga Section

BAILEY, H. Harding ('10; '17; '29), Asst. Mgr., Chattanooga Div., Tenn. Elec. Power Co., Market & 6th Sts.
CABANISS, Walter M. ('24), Signal Mountain Portland Cement Co.
CAMPBELL, Geo. E. ('22), Engr., Charge Design, Wheland Co., S. Broad St.; *for mail,* 1906 Ivy St.
COBURN, Philip J. (J'33), P. O. Box 64.
ERVIN, Thos. C. ('27; '35), Pres., Engr. in Charge Design & Sales, Lucey Mfg. Corp.
HARRIS, Anderson W. ('21; '28), Sales Mgr., Hedges-Walsh-Weidner Co.; *for mail,* 1106 Hanover St.
HYDEN, Eugene B., Jr. (J'33), Instr., Chattanooga Vocational Sch.; *for mail,* 919 Endicott St.
JACKA, Paul G. (J'27), Secy., Plant Mgr., Columbian Iron Wks., 2501 Chestnut St.
McREYNOLDS, Geo. S. (J'29), Plant Engr., U. S. Pipe & Fdy. Co., 27th St. & Chestnut; *for mail* 1517 Mitchell St.
MYERS, Grafton S., Jr. (J'29), 425 Power Bldg.
NELSON, Joe F. (J'30), Hedges-Walsh-Weidner Co. 1032 W. Main St.
REILLY, F. Ward (J'27), Pres., Treas., Sherman & Reilly, Inc., Engrs., 1st & Broad Sts.
SANDERS, Newell ('88), Manager, '02-'05; Vice-President, '27-'29; Prop., Newell Sanders Plow Co.
SIBERT, Martin Luther (J'32), Engrg. Draftsman, Tenn. Valley Authority, New Post Office.

COLUMBIA

WYNNS, Colbert B. (J'35), Engr., Tenn. Electric Power Co.

ELIZABETHTON, Knoxville Section

BROCK, R. C. (J'35), Asst. Engr., N. Am. Rayon Corp.
FREE, Wiley M. ('36), P. O. Box 183.

ROESEL, Arno F. ('26; '34; '35), Plant Engr. Am. Bemberg Corp.; *for mail,* P. O. Box 107.
SCHMIDT, Knute (J'33), Designer, N. Am. Rayon Corp.
TOROK, Elmer ('36), Supt. Power, N. Am. Rayon Corp.

JOHNSON CITY, Knoxville Section

BRYAN, Alan Stuart (J'35), Box 616.
DEADY, Harold E. ('28; '34; '35), R. F. D. 1.
SHEARER, David R. ('17; '35), Mgr., Tenn. East. Elec. Co., 334 E. Main St.

KINGSPORT, Knoxville Section

CALLAN, John ('18; '22; '35), Supt., Power Dept., Tenn. Eastman Corp.
DEAN, Francis F. (J'30), Engr., Steam Power Dept., Tenn. Eastman Corp., Kingsport; *for mail,* 3 Maple Terrace Apt., W. Unaka St., Johnson City.
ELLIS, Jas. ('21; '31), Supt., Engrg. & Serv. Div., Tenn. Eastman Corp.; *for mail,* 1708 Orchard Court.
HALLER, Louis G. ('17; '22; '28), Ch. Engr., Tenn. Eastman Corp.; *for mail,* Kingsport Inn.
HOLYOKE, Wm. L. ('29), Plant Engr., Borden Mill, Inc.
LEVERETTE, W. L. (J'34), P. O. Box 93.
PALMER, Elbridge W. (A'27), Pres., Gen. Mgr., Kingsport Press, Inc., Reedy & Roller Sts.
RODDY, Fred M. (J'28), Design, Tenn. Eastman Corp.; *for mail,* 1330 Watanga St.
WELLS, Arthur S. ('23), Ch. Engr., Mead Fibre Co.; *for mail,* 710 Yadkin St.
WHITE, Jas. C. (A'25), V. P., Gen. Mgr., Tenn. Eastman Corp; *for mail,* 1214 Linville St.
WILCOX, P. S. ('99; '14), V. P., Gen. Mgr., Tenn. Eastman Corp.

KNOXVILLE, Knoxville Section

BEDINGER, Albert F. G. (J'34), Jr. Engr., Tenn. Valley Authority; *for mail,* Cherokee Dr.
BENSCOTER, Daniel B. ('28; '35), Power Sales Engr., Tenn. Pub. Serv. Co., 626 S. Gay St.
BLANDFORD, John B., Jr. (J'21), Coordinator, Tenn. Valley Authority.
BOWMAN, Jas. S. ('26), Head Hyd. Engr., Tenn. Valley Authority, 410 Union Ave.
CARPENTER, Horace ('12), M. E., Tenn. Valley Authority.
CHAMBERS, Wm. R. ('21), M. E., Tenn. Valley Authority; *for mail,* Holston Hills.
FERRIS, Chas. E. ('04), Dean, Engrg., Univ. of Tenn.; *for mail,* 3551 Kingston Pike.
FERRIS, John P. ('26; '35), Acting Dir., Agri. Industries Div., Tenn. Valley Authority, New Sprankle Bldg.
FREEMAN, Perry J. ('08; '14; '19), Principal Matls. Engr., Tenn. Valley Authority; *for mail,* 142 Hillvale Rd.
GIESLER, Jean V. ('23), Ch. Engr., Fulton Sylphon Co.; *for mail,* P. O. Box 104.
GILLHAM, Willard C. ('35), Asst. Agri. Engr., Tenn. Valley Authority; *for mail,* 2308 Laurel Ave.
HUNTER, Edgar L. (J'30), Engr., Design, Tenn. Valley Authority; *for mail,* 143 Underwood Pl.
KADERLY, J. Milo (J'35), Asst. Devel. Engr., Fulton Sylphon Co.; *for mail,* 1738 W. Clinch Ave.
KARP, Raymond E. (AM'35), Construction Plant Div., Tenn. Valley Authority.
LAFORGE, Robt. M. (J'32), Engr. in Indus. & Agric. Research, Tennessee Valley Authority; *for mail,* 206 Adair Dr.
LEWIS, Chas. Fred'k ('20), Mgr., Volunteer Portland Cement Co.; *for mail,* 3033 Fountain Park Blvd.
LLOYD, Jas. M. ('35), M. E., Tenn. Valley Authority; *for mail,* 2109 Lake Ave.
MYNDERSE, C. N. ('25), V. P., Gen. Mgr., Fulton Sylphon Co.; *for mail,* P. O. Box 263.
NIXON, Wm. (J'30), Jr. Matls. Engr., Tenn. Valley Authority.
PIERCE, John V. ('23), Designing, Exper. Dept., Fulton Sylphon Co.; *for mail,* 2500 Washington Pike.
PRICE, Wm. D. (J'31), Jr. Application Examiner, Personnel Dept., Tenn. Valley Authority, Knoxville, Tenn.; *for mail,* Box 243, Blacksburg, Va.
ROBERTS, Jas. F. ('20; '27; '35), Sr. M. E. Design, Tenn. Valley Authority.
SCHWEIER, Arthur ('13; '22), Sr. Hyd. Engr. Tenn. Valley Authority, 514 Union Bldg.
SEARLE, Wm. F., Jr. ('29), 3605 Kingston Pike.
STILL, Wallace Burhman (J'36), 209 Leonard Pl.
SWITZER, John A. ('12), Prof. of Hyd. & Sanitary Engrg., Cons. Engr., Univ. of Tenn.
TAYLOR, Robt. Brooks ('30), Indus. Engr., Acting Ch. Research Sec., Tenn. Valley Authority, Union Ave.
TITUS, E. S. (J'33), M. E. Specifications & Bid Analysis, Constr. Equip., Tenn. Valley Authority, Knoxville; *for mail,* 408 Haworth Pl., Fountain City.
TUCKER, Jesse Mack (J'32), Engr., Charge Refrig. Research, Agri. Industries Div., Tenn. Valley Authority; *for mail,* 2306 E. Glenwood Ave.
WHITE, Duncan A. ('25; '31), Asst. Prof. Mech. Arts, Univ. of Tenn.; *for mail,* 2013 Rose Ave.
WHITE, Jud E. (J'34), M. E., Radio Communications, Tenn. Valley Authority; *for mail,* 2644 E. 5th Ave.
WILKINSON, F. L., Jr. ('26; '29), Prof. M. E., Univ. of Tenn.; *for mail,* Holston Hills.
WOODWARD, Sherman M. ('07), Ch. Water Control Planning Engr., Tenn. Valley Authority.
WORTHINGTON, Chas. G. (J'26), Agri. Industries Div., Tenn. Valley Authority; *for mail,* 1021 Circle Pk.
YAMBERT, D. W. ('29), Assoc. M. E., Constr. Plant Div., Tenn. Valley Authority, Knoxville; *for mail,* 203 Templeton Ave., Fountain City.

MADISON

DEVOE, John (J'32), Engr., Maint. & Design, U. S. Tobacco Co., 1000 Harrison St.; *for mail,* Due West Ave.

MARYVILLE, Knoxville Section

DAVIDSON, Rupert R. (J'30), Mch. Designer, Aluminum Co. of Am., Alcoa; *for mail,* Alexander Ave., Maryville.
HAISLIP, Robt. L. (J'36), Standardization Clerk, Aluminum Co. of Am., Alcoa; *for mail,* 113 Washington Ave., Maryville.
HYDER, Frank K. (J'32), 109 Cedar St.
PATTERSON, Wm. L. (J'36), Draftsman, Aluminum Co. of Am., Alcoa; *for mail,* P. O. Box 173, Maryville.

MEMPHIS, Memphis Section

ALLEN, Thos. H. ('12), Chmn. Bd., Memphis Light & Water Div., P. O. Box 421.
BRONSON, J. S. ('31), Owner, Power Equip. Co., Box 55, Crosstown Sta.
BROOKS, Don F. (J'34), 3444 Bowen Ave.
CABLE, Frank W. ('22; '35), 1024 Joseph Pl.
DRUMMOND, Garrett B. ('29; '30; '32), Jr. Engr., U. S. Engr. Dept., Box 97.
ELLIS, Chas. E. (J'29), Boiler Rm. Oper. Engr., Memphis Power & Light Co., 788 S. 4th St.
FRANKUM, R. O. (J'34), Foreman of Bleachery, Bleaching Plant, Natl. Rose Spring & Mattress Co., 767 Kentucky St.; *for mail,* 347 La Clede St.
FRANSIOLI, V. Garvin (J'34), Reorder Man, Htg. Dept., Sears, Roebuck & Co., 495 N. Watkins St.; *for mail,* 218 N. McLean Blvd.
FRANSIOLI, Walter J., Jr. (J'34), Draftsman, Engrg. Dept., Memphis Power & Light Co., 179 Madison Ave.
HUNGATE, Louis H., Jr. (J'30), Indus. Gas Engr., Memphis Power & Light Co., P. O. Box 388.
KIMBROUGH, G. C., Jr. (J'32), Apt. 3, 152 N. Cooper.
LINDER, Thos. ('24; '34; '35), Res. Engr., Charge Territory, Travelers Ins. Co., of Hartford, Conn.; *for mail,* Apt. 64, 1899 Poplar Ave.
McCORD, Claude M. ('34), Gen. Supt., Water Dept., City of Memphis; *for mail,* 2909 Central Ave.
RICE, Myron W. ('11; '21), Sales Engr., Indus. Div., Memphis Power & Light Co., Madison & 3d Sts.
ROBERTS, Walter H. ('19; '33), Assoc. M. E., U. S. Engrs. Office, Box 97.
RUST, Mack D. ('27; '35), Secy., Treas. & Ch. Engr., Rust Cotton Picker Co., 2369 Florida St.
SCHMIDT, Fred'k J. (J'36), Jr. Engr., Boiler Inspc., U. S. Engrs. Office, Box 97.
SHARP, Campbell K. ('27; '35), Pres. & Gen. Mgr., Sharvania Oil & Grease Corp., 1185 Tulley St.
SHEPHERD, Richard B. H. (J'29), Jr. Engr., U. S. Engrs. Office, Box 97.
TURNER, Guy S. ('15), Pres., Turner & Turner, Box 706, 431 N. Dunlap St.

NASHVILLE

ACKER, Sidney H. ('35), Instr., M. E. Dept., Vanderbilt Univ.
BOYNTON, John E. ('15; '21), Dir., M. E. Dept., Vanderbilt Univ.
COOLIDGE, Richard N. ('27), Gen. Mgr., Cumberland River Sand Co., 10 Fatherland St.; *for mail,* Belle Meade Blvd.
SIMON, Saml. (J'34), Engr., Distribution & Line Ext., Tenn. Elec. Power Co., 605 Church St.; *for mail,* 200—24th Ave., S.
WOOD, H. O. (J'32), 703 Church St.

NORRIS, Knoxville Section

JENSEN, Gordon L. ('30; '35), Tenn. Valley Authority.

OLD HICKORY

MUHLIG, J. R. ('29; '35; '35), Engr., Devel. Wk., Rayon Div., E. I. du Pont de Nemours & Co.; *for mail,* 1210 Overton St.
PETRESCU, Ovid S. (J'30), Supvr., Mech. Exper. Div., E. I. du Pont de Nemours & Co.
SMITH, H. Gordon ('30), Engrg. Dept., E. I. du Pont de Nemours & Co.

PICKWICK DAM

HOUGHTON, Jos. D. ('27; '35), Sr. Pur. Agt., Tenn. Valley Authority; *for mail,* Pickwick Dam.
LUDWIG, Walter W. ('21; '29; '35), Asst. Cost Engr., Pickwick Landing Dam, Tenn. Valley Authority; *for mail,* P. O. Box 275.

ROGERSVILLE

GALL, Wm. R. (J'36), M. E., Instrument Engr., Tenn. Eastman Corp., Kingsport; *for mail,* 117 Broadway, Rogersville.

SHELBYVILLE, Chattanooga Section

PEAVEY, J. M. ('28; '35), Dist. Mgr., Charge Promotion, Constr. & Opera., Tenn. Valley Authority, Gunter Bldg.

SPRING CITY

SEGASER, Chas. L. (J'35), Engr., Charge Exp. & Design, So. Silk Mill; *for mail,* Box 44.

TIPTONVILLE

WINGO, W. B. (J'32), Reelfoot Lake State Park, SP-1.

WHITEHAVEN, Memphis Section

ELAM, Emmett W. (J'32).

TEXAS

AMARILLO, Mid-Continent Section

BURNETT, Earle S. ('13; '35), Sr. M. E., Research & Tech. Consultant, Petroleum & Natural Gas. Div., U. S. Bur. of Mines, Amarillo Helium Plant; *for mail,* 4223 W. 11th Ave.
JOHNSON, Chas. W. (J'30), Mem. Firm, Amarillo Welding & Mch. Wks., 217 N. Polk St.; *for mail,* 1004 S. Louisiana St.

ARANSAS PASS, South Texas Section

BYNUM, Edwin A., Jr. ('20; '26; '35), Ch. Engr., Maint. & Constr., Ingleside Refinery, Humble Oil & Refining Co., Ingleside; *home address,* Box 725, Aransas Pass.

ARP, North Texas Section

CASSITY, John C. (J'36), Asst. Gas Supvr., Sinclair Prairie Oil Co., Sinclair Bldg., Tulsa, Okla.; *for mail,* Box 291, Arp, Tex.

AUSTIN, South Texas Section

BEGEMAN, Myron Louis ('21; '35), Assoc. Prof. M. E., Supt. of Shops, Univ. of Tex.
BRUNS, Jos. L. (J'30), Dept. of M. E., Univ. of Tex.
COOPER, Wm. C. (J'36), 2524 Guadalupe St.
DEGLER, Howard E. ('27), Prof., Chmn., M. E. Dept., Univ. of Tex.
ECKHARDT, Carl J., Jr. (J'29), Prof. M. E., Supt. Utilities, Univ. of Tex.; *for mail,* 1740 University Sta.
HELLER, M. Mendell ('24; '35; '35), Instr. M. E., Univ. of Tex., Box 1743, University Sta.
KNIPPING, R. H. ('19; '26), Supt. Power Plant, City of Austin; *for mail,* R. F. D. Route 3, Box 23.
PERRONE, Saviour (J'35), 1602 E. 6th.
PICKLE, David V. ('31; '33; '35), Head, Dept. of Physical Tests, Texas Highway Dept., W. 34th & M. P. R. R.; *for mail,* 1315 Murray Lane.
SHORT, Byron E. ('27; '30; '35), Asst. Prof. M. E., Univ. of Tex.; *for mail,* University Sta.
VALLANCE, A. ('31), Assoc. Prof. M. E., Univ. of Tex.; *for mail,* 711 W. 34th St.
WALKER, Ralph W. (J'36), Levelman, Bur. of Reclamation, 703 Scarbrough Bldg.; *for mail* 607 Oakland Ave.
WOOLRICH, Willis R. ('19; '23), Dean of Engrg., Univ. of Tex.

BAYTOWN, South Texas Section

GASTON, Audley D. ('25), M. E., Humble Oil & Refining Co.; *for mail,* P. O. Box 444.
WALMSLEY, Geo. (J'22), Supt. Power, Humble Oil & Refining Co.; *for mail,* 504 Ave. D.

BEAUMONT, South Texas Section

FULTON, Geo. R. ('29), Supt. of Prod., Gulf States Utilities Co.
TEXADA, Arnaud P., Jr. (J'36), 711—2nd St.

BEEVILLE, South Texas Section

ALLEN, M. H., Jr. (J'34), Chainman, Engrg. Dept., United Production Corp.; *for mail,* c/o United Gas System, Box 711.

BORGER, Mid-Continent Section

PRICE, Howard W. ('24), V. P., Gen. Mgr., J. M. Huber Corp., P. O. Box 278.

BRADY, South Texas Section

BURROW, E. A. ('16; '25), P. O. Box 765.

BRECKENRIDGE, North Texas Section

BROWN, Chas. H. ('24), Pres. & Mgr., Brown Tool Co., Williams & Caddo Sts.

BROWNSVILLE, South Texas Section

STITT, Wm. T. (J'33), Apprentice Engr., Pan American Airways System; *for mail,* 56 W. St. Francis.

CIBOLO, South Texas Section

SCHLATHER, Max F. (J'32), Civilian Conservation Corps, Camp Co. 2874.

COLLEGE STATION, South Texas Section

CRAWFORD, Chas. W. ('31), Head M. E. Dept., A. & M. College of Tex.
FAIRES, Virgil M. ('28; '32), Prof. M. E., A. & M. College of Tex.
GIESECKE, F. E. ('36), Dir., Tex. Engrg. Experiment Sta., A. & M. College of Tex.
TRAIL, Jas. Arthur (J'29), Instr. M. E., A. & M. College of Tex.
WINGREN, R. M. (J'28), Instr. M. E., A. & M. College of Tex.

CONROE, South Texas Station

WIESS, Byron, Jr. (J'35), Sun Oil Co.

CORPUS CHRISTI, South Texas Section

AVERY, G. Raymond ('26; '33; '35), Supt., Power & Steam Dept., So. Alkali Co.; *for mail,* Route 2, Box 237.
MINER, N. A. ('20; '29), Supt., Pur. Sta., Cent. Power & Light Co., Nixon Bldg.
PETERSON, F. P., Jr. (J'33), M. E. Design & Constr., So. Minerals Corp., 411 N. Broadway; *for mail,* Corpus Christi.
WOLF, Wm. (J'32), Still Man, Corpus Christi Refining Corp.; *for mail,* 1112—13th St.

CORSICANA, North Texas Section

BLAIR, Roy M. (J'26), 701 W. 4th Ave.
DUDA, Oswald ('27), Ch. Engr., Am. Well & Prospecting Co.; *for mail,* P. O. Box 582.
ROBERTS, H. L. ('34), Pres. & Mgr., Oil City Iron Wks.; *for mail,* P. O. Box 465.

DALLAS, North Texas Section

ABBOTT, Seward (J'27), Dist. Sales Mgr., Servel. Inc., of Evansville, Ind.; *for mail,* 1632 Allen Bldg., Dallas, Tex.
BERKLEY, Wm. E. ('21; '26; '35), Dist. Turbine Supvr., Gen. Elec. Co., 1801 N. Lamar St.; *for mail,* 810 Cedar Hill Ave.
BIDDISON, P. McDonald ('15; '17), Cons. Engr., Dallas Gas Bldg.
BOEKELMAN, Hio L. (J'33), 619 Mercantile Bldg.
BOWDRY, Wm. P., Jr. (J'27), Secy.-Treas., Dallas Fdy., Inc., Box 333.
BURBANK, Edw. W. ('19; '21), Manager, '36-'39; Mgr., Allis-Chalmers Mfg. Co., 1515 Santa Fe Bldg.
BUTLER, Frank A. ('19; '35), Sales Engr., Fairbanks, Morse & Co., 1713 Market St.; *for mail.* 3519 Hall St.
CAMPBELL, Jas. H. (J'35), Engrg. Estimator, A. M. Lockett & Co., Ltd., 305 Magnolia Bldg.
CAMPBELL, R. D. ('35), Engr., Fairbanks, Morse & Co.; *for mail,* 2932 Dyer St.
CARGILL, Eugene L., Jr. (J'27), Tex. Co., Box 810.
CHAMBERS, Henry E., Jr. ('31), Dist. Mgr., A. M. Lockett & Co., Ltd., 305 Magnolia Bldg.
CHATTEY, John K. (J'35), Asst. County Engr., Hall of Records.
COLE, Leonard S. (J'35), Air Conditioning Inspr., Pullman Co.; *for mail,* 1201 N. Beckley Ave.
COTTON, H. McL. ('24; '25; '35), 412 Southwestern Life Bldg.
COWLES, Clifford A., Jr. ('17; '25), Pres., Cowles & Co., 509 Mercantile Bldg.
CRANE, Fred (J'34), Guiberson Corp.; *for mail,* 5231 Mission St.
CROWDUS, Robt. R. ('27; '36), Plant Betterment Engr., Dallas Power & Light Co.
ELIZARDI, Frank P. (J'21), Sales Engr., A. M. Lockett & Co., Ltd., 305 Magnolia Bldg.
FULLER, Elbridge W. (J'30), Engr., Buffalo Engrg. Co., 315 S. Harwood.
GADDIS, H. L. ('36), Dist. Sales Mgr., SKF Industries, Inc., 410-12 N. St. Paul.
GREGORY, Wm. Bres (J'22), Sales Engr., A. M. Lockett & Co., Ltd., 305 Magnolia Bldg.
GREVE, Edgar E. ('20), Oil Well Supply Co.; *for mail,* 6729 Golf Dr.
HALLAMAN, Chas. G. (J'35), Student Asst., Pollock Paper & Box Co., 2236 S. Lamar St.; *for mail,* Route 1, Box 90.
HARDY, Norman G. ('13; '14; '19), Supt. Power, Tex. Power & Light Co., Box 962; *for mail.* 4151 Wycliff Ave.
HYDE, Glenn C. ('16; '35), Pres. & Gen. Mgr., So. Ice & Utilities Co., 800 Cotton Exchange Bldg.
JOHNSON, J. P. (J'36), 4221 Rawlins Ave.
JONES, Harlen R. E. (J'31), Engr., Engrg. & Inspc. Div., Travelers Ins. Co., 1610 Republic Bank Bldg.
JUSTICE, F. C. (J'33), Asst. Engr., Engrg. Dept., Dallas Power & Light Co.; *for mail,* 6177 Vickery Blvd.
KEIM, Chas. J. (J'35), Design Engr., Oil Well Supply Co., 2001 N. Lamar St.
LAUTERBACH, Henry, Jr. (J'29), Asst. Ch. Engr., Carrier Corp., 2022 Dryan St.
LEWIS, Ralph E. ('35; '36), Asst. Prof. M. E., So. Methodist Univ.
LITTLE, Lloyd A. (J'28), 1504 Magnolia Bldg.
MAIER, August R. ('30; '35), Asst. Ch. Engr., Oil Well Supply Co., 2001 N. Lamar St.; *for mail,* 5626 Merrimac St.
MARSHALL, S. W., Jr. ('33; '35), Cons. Engr., 1124 Republic Bank Bldg.
McMURRAY, John D., Jr. (J'28), Engr., S. W. Marshall, Jr., Cons. Engr., 1124 Republic Natl. Bank Bldg.
MOELLER, Wm. ('17), Gen. Supt., Lone Star Cement Corp., Santa Fe Bldg.
MURRAY, Fred'k F. ('21; '24; '30), Vice-Pres., Oil Well Supply Co., 2001 N. Lamar St.
NOELL, Milton J. (J'35), Design Engr., M. E., Oil Well Supply Co., 2001 N. Lamar St.; *for mail,* Motor Route 7.
NOYES, Jonathan A. ('16; '25), Mgr., Petroleum Div., Sullivan Mchy. Co., 1914 Commerce St.
PEARSON, Harry R. ('34; '35), Engr., Engrg. Dept., Dallas Power & Light Co.; *for mail* 1510 Hampton Rd.
RABE, Fred'k W. ('18; '24; '35), F. W. Rabe & Assocs., Cons. Engrs.
REID, Walter ('21; '26; '35), Pres., So. Union Gas Co., 1104 Burt Bldg.
ROBINSON, Henry M. ('27; '31), Sr. Engr., Charge Opera., Asst. to Supt., Dallas City Water Works, 112 City Hall; *for mail,* 5203 Tremont St.
RUSH, Warren C. (J'36), Spec. Apprentice, Tex. & Pac. Ry. Co., Dallas; *for mail,* 902 W. Burleson, Marshall.
SALISBURY, R. W. ('16), M. E., Tex. & Pacific Ry. Co.; *for mail,* 5818 Belmont Ave.
SAUCIER, J. Henry, Jr. (J'30), Safety Engr., P. O. Box 2302.
SCHADECK, Edw. W. ('12), Supvg. Engr., So. Ice Co., Inc., 404 S. Ervay St.
SCHENEWERK, J. F. (J'36), Box 212 K, R. 5.
SCHMIDT, Elmer F. ('19; '29), Gen. Supt., Lone Star Gas Co., 1915 Wood St.
SCHUCANY, Oscar Wm. (J'36), 4927 Columbia Ave.
SELLERS, W. M. (J'36), 4824 Abbott Ave.
SHAPIRO, Eli (J'34), 2515 Forest Ave.
SHAUGHNESS, Thos. B. (J'34), Sales & Engrg. Dept., Oil Well Supply Co., 2001 N. Lamar St.; *for mail,* 605 N. Ervay St.
SHIMER, John M. ('31), V. P., Oil Well Supply Co., 2001 N. Lamar St.
SLAYMAKER, Robt. R. ('26; '33; '35), Prof. M. E., Sch. Engrg., So. Methodist Univ.
STEVENS, Geo. W. ('28; '34; '36), Engr., Charge Sales, Southwest. Territory, Novo Eng. Co., Porter St., Lansing, Mich.; *for mail,* 3441 Westminster St., Dallas, Tex.
STILLWELL, Jerry E. ('19; '24), Engr., Am. Petroleum Inst., 1508 Gulf States Bldg.; *for mail,* 7460 San Benito Way, Route 4.
TRUMP, Harry W. ('28), Dist. Mgr., Indus. Div., Timken Roller Bearing Co., 409 Olive St.

DIRECT, North Texas Section

BRIGGS, Homer (J'36), R. F. D. 2.

EL PASO

HEPBURN, Jas. W. (J'29), Worthington Co., Inc., 210 San Francisco St.
LEARMONTH, Alex. Chas. ('18; '35), Ch. Engr., Power Sta., El Paso Elec. Co.; *for mail,* 2901 San Diego St.
LOCKHART, Ernest Ray (J'34), 1800 E. Nevada St.
MADLEM, D. W. ('23; '35), V. P., El Paso Ice & Refrig. Co., Ch. Engr., Peyton Packing Co., 210 N. Ochoa St.; *for mail,* P. O Box 1107.
NEVINS, Ennis ('25), M. E., El Paso Water Wks.
PLAPP, Elmer B. ('19; '25; '35), Power & Combustion Engr., Am. Smelting & Refining Co., Box 1111.

FORT SAM HOUSTON, South Texas Section

CATTS, Gordon Rives, Jr. (J'35), Sales Asst., Hdq. Sales Wk., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.; *home address,* c/o Col. G. R. Catts, 217 Artillery Post, Ft. Sam Houston, Tex.

FORT WORTH, North Texas Section

CASSELL, J. L. (J'35), 1414 W. Humboldt.
CORDELL, Philip M. ('31; '35), Engr., Power Sales & Promotion, Tex. Elec. Serv. Co., 408 Elec. Bldg.
FITZGERALD, Chas. ('18; '22), Asst. to V. P., Sinclair Refining Co., Pipe Line Dept., P. O. Box 1990.
JENKINS, J. Beaumont (J'34), Engr., Prod. Dept., Stanolind Oil & Gas Co., Box 1410.
McKINNEY, Geo. C. (J'29), Valuation Engr., Pritchard & Abbott, 1209 Ft. Worth Natl. Bank Bldg.
NELSON, Robt. T. (J'35), Test. Engr., Texas Elec. Serv. Co., Elec. Bldg.; *for mail,* 408 May St.
RASMUSEN, J. E. ('18), V. P. & Gen. Mgr., Baker Ice. Mch. Co. of Tex., 509 E. 3d St.
THOMAS, Julian B. ('26), V. P., Charge Opera., Tex. Elec. Serv. Co., Elec. Bldg.
WERNER, Richard ('25; '35), Cons. Engr., 316 W. T. Waggoner Bldg.

FREEPORT, South Texas Section

FITZHUGH, Robt. R. (J'36), M. E., Freeport Sulphur Co.
SCHLESER, Erich (J'36), Box 356.

GALVESTON, South Texas Section

GILLESPIE, Fontaine M. ('22; '35), 2602 Ave. N.
GRAY, Harry ('28), Cons. Mech. & Mar. Engr., 26 Marine Bldg.
GRAY, John Edw. (J'31), Asst. Supt., Todd-Galveston Dry Docks, Inc.; *for mail,* 3529 Ave. P.
McCARTHY, E. W. (J'32), M. E., Charge Design & Maint., Stand. Dredging Co., 323 Guaranty Bldg.

HARLINGEN

EBLEN, Wm. F. ('25), Pres., Valley Petroleum Co., P. O. Box 245.

HOUSTON, South Texas Section

ALLEN, Herbert (J'36), Ch. Engr., Cameron Iron Wks., P. O. Box 1212.
ALLIGER, Wm. T. ('26), Mfrs. Agt., 4421 Rusk Ave.
ALTON, Darrel D. ('24; '35), Spec. Engr., Design & Maint., So. Pac. Lines, 913 Franklin Ave.; *for mail,* 1130 Banks St.
BARNES, Arthur F. ('10; '16; '19), M. E. & Mgr., Tex. Engrg. Co., 726 Elec. Bldg.
BROOKE, Chase J., Jr. (J'36), Salesman, Oilfield Div., Gardner-Denver Co., Quincy, Ill.; *for mail,* 2308 Texas Ave., Houston, Tex.
BURR, Arthur H. (J'30), Instr., M. E., Rice Inst.; *for mail,* 6717 Vanderbilt St.
CHRISTMAN, Carlisle J. ('31; '35), 1015 Holman Ave.
COCHRAN, Wm. B. (J'35), Straus-Frank Co., 1819 Travis St.; *for mail,* R. F. D. 1, Box 16, Tel. Rd.
DOGGETT, John, Jr. (J'36), 6636 Buffalo Speedway.
DURWARD, E. Stanley ('15; '35), Equip. Engr., Shell Petroleum Corp., Shell Bldg., P. O. Box 2099.
DVORAK, J. (J'35), Draftsman & Designer, Humble Oil & Refining Co., Baytown; *for mail,* 6111 Washington Ave., Houston.
ELROD, Henry E. ('11), Cons. Engr., 316 Petroleum Bldg.
EVANS, Seth ('29), E. E., Hughes Tool Co.
FLETCHER, Harold W. ('16; '24), Ch. Engr., Hughes Tool Co., Houston; *for mail,* Webster.
GARRISON, R. M. ('29; '33; '36), Research Engr., J. H. McEvoy & Co., 600 Milby St.; *for mail,* Rm. 511, Plaza Hotel.
HARGON, Swanson (J'36), 4950 Polk Ave.
HARRINGTON, G. G. ('22; '33), Ch. Engr., Reed Roller Bit Co., Mack St.
HARTWELL, Arthur E. ('11; '13; '22), Pres., Treas., Hartwell Iron Wks., P. O. Box 105.
HERBERT, Wm. F. ('25; '32; '35), M. E., Petroleum Engrg. Dept., Tex. Co., Box 2332.
HIEBELER, Harry G. ('19; '25; '33), Asst. Supt. Power, Houston Ltg. & Power Co.; *for mail,* 1648 Colquitt St.
HULL, Burton E. ('16), Pres., Tex. Pipe Line Co., Tex.-Empire Pipe Line Co., P. O. Box 2332.
JANCO, Nathan (J'32), Research Engr., Charge Engrg. Design, Reed Roller Bit Co.
JOHNSON, Edw. Wm. (J'34), Mar. Engr., Petroleum Navigation Co.; *for mail,* 7305 Harrisburg Blvd.
KINCADE, Elmer C. ('13; '35), V. P., Gulf Pipe Line Co., Drawer 2100.
KING, Joe J. (J'28), Asst. Supt. of Compressor Stas., United Gas System, Rusk Bldg.
KNUDSON, M. C. (J'32), 212 Lenox St.
KROPP, Richard (J'23), Engr., So. Eng. & Pump Co.; *for mail,* 5501 Brady St.
KULDELL, Rudolph C. ('23), Pres., Hughes Tool Co., Box 2539.
LEVERETT, Wilton H. (J'28), 2306 Rosewood.
LEVY, Maurice W. (J'30), Shell Petroleum Corp., P. O. Box 5548.
LEWIS, Chas. Finley (J'28), P. O. Box 262.

MARKLE, Franklin S. (J'29), Walworth Co., 1117 2nd Natl. Bank Bldg.
MASON, John W., Jr. ('21; '24; '35), Dist Mgr., Combustion Engrg. Co., Inc., 818 Esperson Bldg.
MATHIEU, Jean (J'29), 2515 Isabella, L. 9629.
McDONALD, W. A. ('20), Supt Power, Houston Light & Power Co.
McKEAN, Chas. Vincent (J'35), Draftsman, Engrg. Dept., Humble Oil & Refining Co., Baytown; *for mail*, 2113 E. Alabama, Houston.
MILLER, Paul Bertolet ('22), 2nd V. P., Atlantic Gulf & Pac. Co.; *for mail*, 1917 Ruth St.
MILLER, Terrell V. (J'35), 1917 Ruth St.
MOLLER, H. Fred'k ('23; '25; '35), Plant Engr., Charge Plant Devel., Reed Roller Bit Co., Box 2119.
MULLER, F. G. D. ('30), V. P., Charge Design Staytite Co., 3608 Polk Ave.
MULLER, Oke Wm. (J'34), 1920 W. Lamar St.
NETHERWOOD, Jos. S. ('14; '21; '30), Asst. Supt., Motive Power & Equip., So. Pac. Lines in Texas & Louisiana, 913 Franklin Ave.
NEUHAUS, Ralph (J'22), Asst. Ch. Engr., Hughes Tool Co., 300 Hughes St.
NEVILL, Gale E. (J'28), Engr., Head, Design Dept., Natl.-Superior Co., 6229 Navigation Blvd.
O'DONNELL, Lawrence (J'27), 2618 Isabella.
PARMESAN, Daniel J. (J'33), 3610 Barnes St.
POUND, Jose. H. ('15; '23), Prof. M. E., Rice Inst.; *for mail*, 1110 Autrey St.
POWER, John A. ('33), Supt., Motive Power & Equip., So. Pacific Lines in Texas & Louisiana; *for mail*, 3719 Audubon Pl.
PUFFER, Kenneth L. (J'29), M. N. Dannenbaum Co., Shell Bldg.
RAHM, Fenton D. (A'23), Sales Mgr., A. M. Lockett & Co., Ltd., 1014 Elec. Bldg.
RITTER, Paul A., Jr. ('34; '35), 1406 Esperson Bldg.
ROBERTSON, John Marshall ('21; '33), Sales Mgr., Indus. Dept., Houston Natural Gas Co.; *for mail*, 2805 Rosedale.
ROSEBRUGH, Crawford M. ('29), Ch. Engr., Pipe Line, Gulf Refining Co.; *for mail*, 2020 Harvard St.
SCOTT, W. W. ('36), Ch. Petroleum Engr., Humble Oil & Refining Co.
SOUNITZA, Wladimir ('24; '28), Ch. Engr., Mchy. Div., Emsco Derrick & Equip. Co., P. O. Box 184.
STEEN, Arthur B., Jr. (J'27), Draftsman, Humble Pipe Line Co., 630 Humble Bldg.; *for mail*, 2719 Isabella Ave.
SWINFORD, Jerome K. (J'23), M. E., Plant Betterment, Houston Ltg. & Power Co., Elec. Bldg.; *for mail*, 2529 Prospect Ave.
THOMPSON, Herbert L. ('12; '21), H. L. Thompson Co.; *for mail*, 404 Avondale.
WHEELER, Louis J. ('28), Sput., Charge Opera., Lone Star Cement Corp., P. O. Box 1718.
WILHOIT, L. M. (J'36), Serv. Engr., Otis Pressure Control, Inc., 6729 Navigation Blvd.
WILLIAMS, Marvin W. (J'36), M. E., Sales Dept., Hughes Tool Co.
WINANS, Robt. H. (J'30), Sales Engr., A. M. Lockett & Co., Ltd., 1014 Elec. Bldg.

LAREDO

NETZER, Paul M. (J'29), M. E., Charge Design & Maint., J. C. Netzer Co., 2001 Scott St.

LONGVIEW, North Texas Section

DAVIS, Louis F. (J'35), 41 Covington Dr.
JONES, Keith Edw. ('26; '35), Box 1098.
ROBINSON, Francis N. (J'36), Sales Engr., Field Engrg., Continental Supply Co. of Dallas; *for mail*, c/o Continental Supply Co.

LUBBOCK, North Texas Section

DOUGHTIE, Venton L. ('21; '32; '35), Prof. M. E., Tex. Tech. College.
GODEKE, H. F. ('35), Prof. M. E., Head Dept., Tex. Tech. College.
HARDGRAVE, J. C. ('30; '35), M. E. Dept., Tex. Tech. College.
ST. CLAIR, Oscar A. ('30), Prof. & Head Dept. Indus. Engrg. & Engrg. Drawing, Tex. Tech. College.
SVENSEN, Carl Lars ('11; '19), P. O. Box 933.

LUFKIN, South Texas Section

HESS, Ernest E. ('17; '25; '35), Engr., Designing, Drafting, Lufkin Fdy. & Mch. Co.; *for mail*, Route 3.
TROUT, Walter C. (A'19), Pres., Mgr., Lufkin Fdy. & Mch. Co.

MARSHALL, North Texas Section

HOLLIS, Hugh Denise (J'26), 310 S. College.

MERCEDES, South Texas Section

SHAW, Jas. C. ('09), V. P. & Plant Mgr., Mercedes Concrete Pipe Co.; *for mail*, 908 Missouri Ave.
SHAW, Wm. F. ('13), V. P. & Gen. Mgr., Am. Rio Grande Land & Irrigation Co.

MIDLAND

POLLARD, Terence A. (J'35), Petroleum Engr., The Calif. Co., Drawer R.

NEDERLAND, South Texas Section

SAWYER, Alfred J. (J'32), M. E., Charge Inspc., Pure Oil Co., P. O. Box 237.

NEWGULF, South Texas Section

LOWTHER, Geo. W. (J'29), M. E., Power Plant, Tex. Gulf Sulphur Co.
ORR, Carol Lister ('21; '23; '29), Power Plant Mgr., Tex. Gulf Sulphur Co.; *for mail*, Newgulf.
PRESTON, Walter B. ('28; '34; '35), Asst. Power Plant Mgr., Tex. Gulf Sulphur Co.; *for mail*, Newgulf.

PALESTINE, North Texas Section

BAILEY, Thos. B., Jr. (J'36), 408 Park Ave.

PAMPA, Mid-Continent Section

RODGERS, W. C. (J'36), Apprentice, Prod. Div., Phillips Petroleum Co., Rt. 2.

PASADENA, South Texas Section

ALLISON, A. W., Jr. (J'35), Champion Paper & Fibre Co., Box 347.
CRUTE, Wm. R. ('10; '16; '35), Mgr., Champion Paper & Fibre Co.

PILOT POINT, North Texas Section

YOUNG, Bruce B. (J'33), V. P., Pilot Point Refining Co.

PORT ARTHUR, South Texas Section

ELLIOTT, John S. (J'33), 3211—5th St.
FLEMING, Jas. C. (J'28), M. E., Gulf Oil Corp.; *for mail*, 516—5th Ave.
HEBERT, Martin, Jr. (J'36), M. E., Asst. Welding Engr., Gulf Oil Corp.; *for mail*, 2330—6th St.
LEVERETT, Frank M. ('22; '29), Power Engr., Tex. Co., Box 712.
LOWTHER, W. G. (J'35), 1637 Proctor.
MANGELSDORF, Theo. A. ('30; '35), 3332—7th St.
STEPHENS, Ernest L. (J'28), M. E., Charge Maint. Effic., Tex. Co., Box 712.
WHITE, Karl K., Jr. (J'35), M. E., Refinery Equip. Inspec., Refining Div., Gulf Oil Corp.; *for mail*, 1747—5th St.

PORT NECHES, South Texas Section

HUNT, Paul N. (J'32), M. E., Tex. Co.

RANDOLPH FIELD, South Texas Section

WARREN, Roy E. (J'36), Flying Cadet Detachment, Randolph Field.

ROSHARON, South Texas Section

COLLES, Geo. W. ('95; '01), Gen. Agent & Mgr., Rose of Sharon Garden Ranch, Rosharon; *for mail*, Angleton.

SAN ANGELO

KENLEY, Brents E. (J'35), Box 563.

SAN ANTONIO, South Texas Section

BERETTA, John W. ('32), Pres., J. W. Beretta Engrs., Inc., 1203 Natl. Bank of Commerce Bldg.
BREAKER, Ernest R. ('25), Mem. Firm, Breaker & Blomeyer, Contrs., 510 Cumberland Rd.
DIVER, M. L. ('22), Cons. Engr., P. O. Box 1016.
PROSSEN, Peter Jos. (J'30), 413 Hunstock St.
SHAW, Silas F. ('19), Cons. Engr., Westgate Oil Co., 301 Terrell Rd.
TUTTLE, Wm. B. ('05), Chmn. Bd. Dirs., San Antonio Pub. Serv. Co., 201 N. St. Mary's St.

SUGAR LAND, South Texas Section

HILL, Jas. T. ('32; '35), Supt. Power Plant, Fort Bend Utilities Co.

SWEETWATER

HUFFORD, Jas. David (J'36), M. E., Charge Tile Prod. & Plant Engrg., U. S. Gypsum Co.; *for mail*, Macie Hotel.
YOUNGCLAUS, Wm. P., Jr. (J'35), Bd. Plant Clerk & Tester, U. S. Gypsum Co.; *for mail*, 400 E. Broadway.

TEMPLE, North Texas Section

NORRIS, John Alexander ('21), Ch. Engr., Genl. Mgr., Brazos River Conservation & Reclamation Dist., Kyle Hotel Bldg.

TEXARKANA, Mid-Continent Section

CLYDE, Jos. Dennis ('21; '35), Div. Gen. Foreman, Tex. & Pac. Ry. Co., Texarkana; *for mail*, Apt. K, 1507 Texas St., Fort Worth.

TEXAS CITY, South Texas Section

SCHAPIRO, Sylvan B. (J'26), Asst. Gen. Supt., Pan-Am. Refining Corp., P. O. Box 401.
SULLENDER, Wm. A. (J'34), Engr., Pan-Am. Refining Corp.; *for mail*, P. O. Box 983.

TEXON

POSGATE, Jas. S. ('12), Cons. Engr., Big Lake Oil Co., Texon, Reagan Co.

WHARTON, South Texas Section

JONES, K. A., Jr. (J'31), Engr. in Power Plant, Baker & Williams; *for mail*, Box 691.

WHITTENBERG, Mid-Continent Section

ROACH, Jack W. (J'36), Jr. Engr., Maint. & Design, Alamo Refinery, Phillips Petroleum Co.; *for mail*, P. O. Box 112.

WICHITA FALLS, North Texas Section

COBB, Jas. A., Jr. (J'31), Jr. Engr., Mch. Design, Wilson Mfg. Co., 600 N. Scott; *for mail*, 1654 McGregor St.
WRAY, Harold C. (J'34), Ch. Draftsman, Wilson Mfg. Co., 600 N. Scott; *for mail*, 2173½ Ave. J.

WOLFE CITY, North Texas Section

PROVINE, Clarence R. (J'36), Commercial Salesman, Houston Ltg. & Power Co., 1016 Walker St., Houston; *for mail*, Wolfe City.

UTAH

GARFIELD, Utah Section

EGLESTON, Marvin P. (J'33), Plant Engr., Am. Smelting & Refining Co.
STEWART, Norman L. ('22), Asst. Ch. Engr., Am. Smelting & Refining Co., Garfield; *for mail*, 57 Hillcrest Apts., Salt Lake City.

GREEN RIVER, Utah Section

BEEBE, Claude R. (J'34).

MAMMOTH, Utah Section

HASSELL, Howard J. (J'28).

MURRAY, Utah Section

EK, Alma ('17; '22), 726 W. 48th St.

OGDEN

FOWLER, R. Walter (J'35), 326 Parry St.

SALT LAKE CITY, Utah Section

BALIFF, Jack (J'33), 157 N. State St.
BECKSTRAND, Elias H. ('08), Prof. M. E., Univ. of Utah.
BILLETER, Julius (J'28), Asst. Engr., Salt Lake City Corp., 401 City & County Bldg.
BLETZACKER, Harry T. ('33; '35), Ch. Engr., Bletzacker & Bletzacker, 50 E. 5th St., S.
BROWNING, Rowland E. (J'35), 1839 S. 4th St., E.
CLARK, Raymond Wallace (J'35), Engr., Designing, U. S. Smelting, Refining & Min. Co., 1005 Newhouse Bldg.; *for mail*, Apt. 4, 352 E. 4th South St.
COPE, Wm. J. ('27; '32), Assoc. Prof., Univ. of Utah.
EBERLY, Clarence M. (J'29), Engr. Asst., Mountain States Tel. & Tel. Co.; *for mail*, 963 E. 8th St., S.
EGLESTON, O. J. ('16), Hotel Utah.
ERICKSON, Arthur ('26), 135—6th East St.
FERGUSON, Hugh M. ('27), Asst. to Commercial Mgr., Utah Power & Light Co., 524 Kearns Bldg.; *for mail*, 1264 E. 5th South St.
FRANKLIN, Edw. J. ('13), Cons. M. E., Utah Copper Co., Nev. Consltd. Copper Corp. & Gallup Am. Coal Co., 719 Kearns Bldg.
FREWIN, Leroy (J'36), Draftsman, Am. Smelting & Refining Co., Garfield Plant, Garfield; *for mail*, 780 N. 2nd St., W.
HOGAN, Mervin B. (J'30), Assoc. Prof. M. E., Univ. of Utah.
JACOBSEN, Saml. Clark (J'34), Foreman, New & Used Truck Dept., Gen. Motors Truck Co., 974 S. Main St.; *for mail*, 174 K St.

LANDES, Herbert D. (A'28), Pres., Landes Tractor & Equip. Co., 236 W. S. Temple St.
LANG, John ('32), Owner, Mgr., Lang Co., 267 W. 1st St., S.; *for mail*, 1100 S. 15th East St.
LILLIE, Grant W. ('01; '21), 1340 Sunnyside Ave.
NELDEN, Richard M. (J'36), Sr. Rodman, Utah State Rd. Comm., Harrison & 23rd, Ogden; *for mail*, 1568 Garfield Ave., Salt Lake City.
NUNN, P. N. ('04), Pres., Telluride Power Co., 1309 Walker Bank Bldg., Salt Lake City, Utah; *for mail*, 2440 Albatross St., San Diego, Calif.
PACE, Elton W. (J'31), Secy.-Treas., Mfrs. Sales & Service Co., 144 S. 5th West St.
PARKER, Geo. Adelbert ('27), Asst. to Cons. M. E., Utah Copper Co., 719 Kearns Bldg.
PARSONS, Harold C. (J'31), M. E., Lang Co., 267 W. 1st St., S.; *for mail*, 134 K St.
RATHJENS, G. W. ('16), Ch. Engr., U. S. Smelting, Refining & Min. Co.; *for mail*, Box 175.
ROBERTS, Jules D., Jr. ('27), V. P., Distribution Div., Mountain Fuel Supply Co., 36 S. State St.
SHARP, J. Cecil (J'35), Draftsman, Utah State Rd. Comm., State Capitol Bldg.; *for mail*, 461—1st Ave.
THOMSON, Hugh M. (J'33), Asst. Chemist, Plant Prod., Utah Oil Refining Co.; *for mail*, 1056 Yale Ave.
TRASK, Walter H., Jr. ('08; '24), M. E., Salt Lake Hardware Co., 101 N. 3rd St., W.; *for mail*, 1341—2nd Ave.
TURPIN, Wayne D. (J'30), 580 S. 12th East St.
WILDE, Dale R. (J'36), Jr. Engr., Design, Hawley-Richardson-Williams Co., 204 Dooly Bldg.; *for mail*, 1423 Michigan Ave.

STOCKTON, Utah Section

KELSEY, W. H. ('23), Ch. Engr., Gen. Supt., Combined Metals Reduction Co.

VERMONT

BELLOWS FALLS, Green Mountain Section

LOVE, Clyde P. (J'32), M. E., Charge Opera., Maint. & Const., Seaboard Minerals Corp., P. O. Box 162; *for mail*, 16 Atkinson St.

BENNINGTON, Green Mountain Section

BEACH, Chas. S. (J'85), Designer & Machinist, 753 Main St.
TSCHORN, Frank H. (J'31), Supt. Bldgs. & Grounds, Bennington College.

BURLINGTON, Green Mountain Section

ESPY, Melvin Paul (J'34), Jr. Agri. Engr., Soil Conservation Serv., U. S. Dept. Agri.; *for mail*, 7 School St.
SPEAR, F. Harold (J'34), 18 Russell St.
SUSSDORFF, Edmund L. ('23; '26), Asst. Prof. M. E., Univ. of Vt., Burlington; *for mail*, Essex Junction.

NORTH FERRISBURG, Green Mountain Section

BRECKENRIDGE, L. P. ('90; F'36), Vice-President, '07-'09.

NORTHFIELD, Green Mountain Section

ADAMS, Porter H. ('16; '26; '28), Pres., Norwich Univ.

POULTNEY, Green Mountain Section

WINZENBURGER, Ernst A. (J'30), Prof. Math. & Physics, Green Mountain Jr. College.

PROCTOR, Green Mountain Section

BELCHER, Henry C. ('22), Ch. Engr., Vt. Marble Co.; *for mail*, 9 School St.
PROCTOR, Redfield ('05; A'06), Pres., Vt. Marble Co.

RUTLAND, Green Mountain Section

O'BRIEN, Patrick J. (J'27), 48 Allen St.
PATCH, Fred R. ('29), Pres., Madras Marble Corp., Sylacauga, Ala. & Patch-Wegner Co., Inc., Rutland, Vt.; *for mail*, 137 N. Main St., Rutland.

ST. JOHNSBURY, Green Mountain Section

JACOBUS, A. B. ('29), E. & T. Fairbanks & Co.
TOWLE, Harold P. (J'32), Design Draftsman, E. & T. Fairbanks & Co., Mechanics Sq.; *for mail*, 37 Cliff St.

SPRINGFIELD, Green Mountain Section

ARMS, Merton H. ('31), Designing Engr., Bryant Chucking Grinder Co.; *for mail*, 190 Summer St.
FELLOWS, Edwin R. ('98), Pres., Gen. Mgr., Fellows Gear Shaper Co.; *for mail*, 61 Cherry Hill.
FERSING, Leif ('30; '35), Research Engr., Jones & Lamson Mch. Co.; *for mail*, 2 La France St.
FINN, Howard R. (J'32), Serv. Engr., Jones & Lamson Mch. Co.; *for mail*, 98 Wall St.
FLANDERS, Ralph E. ('08; '14; F'16), Manager, '26-'29; Vice-President, '29-'31; President, '35; *Worcester Reed Warner Medallist*, '34; Pres., Jones & Lamson Mch. Co.
HAMILTON, Douglas T. ('16; '20), Adv. Mgr., Fellows Gear Shaper Co.; *for mail*, 100 Summer St.
JOHNSON, Jos. Blaine ('18; '24; '28), Ch. Engr., Bryant Chucking Grinder Co., 257 Clinton St.
LOVEJOY, Fred P. ('17), Pres., Lovejoy Tool Co., Inc., Main St.; *for mail*, 172 Summer St.
LOVELY, John E. ('16; '25), Ch. Engr., Jones & Lamson Mch. Co.; *for mail*, 25 Cherry Hill.
PAULING, Frederic W. (J'36), Training Course, Fellows Gear Shaper Co.; Springfield, Vt.; *for mail*, 12 School St., Springfield, Mass.
WOOLSON, Wm. D. (A'97), Treas., Jones & Lamson Mch. Co.

WINDSOR, Green Mountain Section

DEWELL, Chas. J. ('24; '28), Maint. Engr., Natl. Acme Co.

VIRGINIA

ALEXANDRIA, Washington, D. C., Section

ALDRICH, Horace E ('28), Safety Supvr., Va. Pub. Serv. Co., 117 S. Washington St.
ATKINSON, R. L. ('28), M. E., Chief Div. Field Equip., Geol. Survey, Dept. of Interior, 18 & F Sts., N. W., Washington, D. C.; *home address*, 36 Mason Ave., Alexandria, Va.

ARLINGTON, Washington, D. C., Section

RYDER, Edw. I. (J'33), 2051 Wilson Blvd.
SAGUI, Andrew J. ('23; '26; '35), Asst. Mar. Engr., Navy Dept., 17th & Constitution Ave., Washington, D. C.; *for mail*, 1729 Queens Lane, Arlington, Va.

BLACKSBURG, Virginia Section

BLACKMAN, Robt. C. (J'36), Fellowship, Fuel Engrg., Va. Poly. Inst.; *for mail*, B. T. U. House, Box 82.
CONNER, N. W. (J'31), Asst. Prof., Va. Poly. Inst.
ELLIS, Weldon T. ('08; '12), Prof. Power Engrg. & Mch. Design, Va. Poly. Inst.; *for mail*, Blacksburg.
HYDE, Harlan W. (J'36), Graduate Student, Va. Poly. Inst., Stone Dormitory.
JONES, Jas. Bernard ('23; '35), Assoc. Prof. M. E., Head of Dept., Va. Poly. Inst., Box 205.
NORRIS, Earle B. ('15), Dean Engrg., Va. Poly. Inst.; *for mail*, Box 26.
NORTON, Paul T., Jr. ('33), Prof. Indus. Engrg., Va. Poly. Inst.; *for mail*, P. O. Box 183.
ROOP, Frank S., Jr. (J'35), Instr., M. E., Va. Poly. Inst.

CAPE CHARLES, Virginia Section

RUSSELL, H. H., Jr. (J'32), Mgr., Edinburg Hardwood Lumber Co., Wagram, N. C.; *home address*, 17 Strawberry St., Cape Charles, Va.

CHARLOTTESVILLE, Virginia Section

EDWARDS, T. W. (J'34), Jr. Hyd. Engr., Water Resources & Power, Box 1365, University; *for mail*, 1249 Park St., Charlottesville.
MORSE, Fred'k T. ('25; '31; '35), R. F. D. 3.
STROUD, M. G. (J'35), Student Engr., U. S. Bur. of Pub. Rds., Washington, D. C.; *for mail*, Box 171, Charlottesville, Va.

CISMONT, Virginia Section

ROBINSON, John H. (J'34).

DANVILLE, Virginia Section

CUNNINGHAM, Geo. H. ('10; '14), Box 818.

FARMVILLE, Virginia Section

BROWN, Chas. L. ('25), Cons. Engr., 309 St. George St.

FORDWICK, West Virginia Section

JOHNSON, Henry A., Jr. (J'36), Packing Inspr., Lehigh Portland Cement Co.; *for mail*, Fordwick.

FORT BELVOIR, Virginia Section

EISTER, W. Donald (J'34), Lieut., 5th Engr. Regiment, U. S. A., Ft. Belvoir.

FORTRESS MONROE, Virginia Section

BURTON, Geo. H., Jr. (J'34), 2nd Lieut., Coast Artillery Corps., U. S. A., Randolph Hall, Ft. Monroe.

GLEN LYN, Virginia Section

LAWRENCE, Moses P. ('24), Supt. Generating Plant., Appalachian Elec. Power Co.

HAMPTON, Virginia Section

ALLISON, John M. (J'29), Research Engr., Hydrodynamics, Natl. Advisory Com. for Aero., Langley Memorial Aero. Lab., Langley Field; *for mail*, 355 Creek Ave.
BELL, Joe Warren (J'31), Jr. M. E., Natl. Advisory Com. for Aero., Langley Field, Hampton; *for mail*, P. O. Box 35, Buckroe Beach.
CLARK, J. D. (J'36), Research Test Engr., Natl. Advisory Com. for Aero., Langley Field; *for mail*, 66 Linden Ave.
EBERT, John W., Jr. (J'35), Jr. Scientific Aide, Hydrodynamics Div., Langley Memorial Aero. Lab., Langley Field; *for mail*, 442 Lee St.
HAESSLER, Walter M. (J'29), Jr. M. E., Aero. Engineer, Natl. Advisory Com. for Aero., Langley Field; *for mail*, 120 Pocahontas Pl.
MILLER, Elton W. ('19), Ch. Aerodynamics, Natl. Advisory Com. for Aero., Langley Field.
PEPOON, Philip W. (J'33), Jr. Aero. Engr., Natl. Advisory Com. for Aero., Langley Memorial Aero. Lab., Langley Field; *for mail*, 141 Melrose Ave.
WYCKOFF, John W. (J'31), 112 Victoria Ave.

HILTON VILLAGE, Virginia Section

TERRY, R. V. ('31), Hyd. Engr., Charge Design, Newport News Shipbldg. & Dry Dock Co., Newport News; *for mail*, P. O. Box 472, Hilton Village.

HOPEWELL, Virginia Section

BERG, Gerhard P. (J'31), Designer & Draftsman, Nitrogen Div., Solvay Process Co., Hopewell, Va.; *for mail*, 147 E. 89th St., New York, N. Y.
BOWEN, Ernest W. ('25; '31; '35), Engr., Solvay Process Co.
BRAND, Horace H. ('36), Apt. 8, City Point Court.
CLARK, Frank C. ('13), Gen. Mgr., Atmospheric Nitrogen Corp., Hopewell; *for mail*, 1725 Fairfax Ave., Petersburg.
DUNCAN, John M. ('21; '35), Engr., Nitrogen Div., Solvay Process Co.
EDWARDS, Clive L. ('30; '31; '35), M. E. Drafting Dept., Solvay Process Co.; *for mail*, R. F. D. 1.
ERICKSON, Harold V. (J'31), Asst. Foreman, Gas Production, Solvay Process Co.; *for mail*, Box 1332.
HANSON, L. C. ('31; '35; '35), Foreman, Atmospheric Nitrogen Corp.; *for mail*, 104 Crescent Ave.
JOHNSON, Francis E. R. (J'29), Accountant, Atmospheric Nitrogen Corp.; *for mail*, 201 Prince George Ave.
KEANE, Arthur F. ('29), Engr., Charge Design, Nitrogen Div., Solvay Process Co., Hopewell; *for mail*, 1755 S. Sycamore St., Petersburg.
KISTLER, Norman Leroy (J'28), Operator, Atmospheric Nitrogen Corp., Hopewell; *for mail*, 1630 Berkeley Ave., Petersburg.
KNISKERN, Walter H. ('05; '12), Dir. of Devel., Nitrogen Div., Solvay Process Co.
McCUTCHEON, Adam C. ('22), Asst. M. M., Solvay Process Co., Hopewell; *for mail*, 1711 Monticello Ave., Petersburg.
MORRIS, Thos. C. ('18), Ch. Engr., Design & Constr., Nitrogen Div., Solvay Process Co.
NOVIKOFF, Igor A. (J'28), Jr. Engr., Atmospheric Nitrogen Corp., Hopewell; *for mail*, 821 Shepard St., Petersburg.
O'LEARY, John J. ('30), Mgr., Prod., Solvay Process Co.
ROGERS, Donald A. ('24; '33), Chem. Engr., Charge Design, Nitrogen Div., Solvay Process Co.
SCHULTZE, Geo. W. (J'28), M. E., Nitrogen Div., Solvay Process Co.; *for mail*, Box 1247.
SEGL, Walter E. ('23; '35), Res. Engr., Charge Maint., Power & Constr., Hercules Powder Co.
SZIKLAS, Endre ('26; '32; '35), Asst. Engr. Design, Nitrogen Div., Solvay Process Co., Hopewell; *for mail*, 1726 Berkeley Ave., Petersburg.
TROTTER, Arthur H. ('14), Asst. Plant Engr., Maint., Solvay Process Co.
TWITCHELL, Clarence H. ('21; '35), Asst. M. E., Atmospheric Nitrogen Corp., Box 1087.
YOUELL, Leonard L. ('22; '25; '35), Steam Engr., Devel. Dept., Nitrogen Div., Solvay Process Co.

IVANHOE

NIEBANCK, Richard J., Jr. ('23; '28; '35), Plant Engr., Charge Engrg. & Maint., Natl. Carbide Corp.; *for mail*, Box 97.

LEXINGTON, Virginia Section

TRINKLE, Lieut.-Col. R. J. ('30; '35), Assoc. Prof. M. E., E. E., Va. Military Inst.; *for mail*, 606 Stonewall St.

LYNCHBURG, Virginia Section

CAPRON, John D. ('26; '35), Pres., Glamorgan Pipe & Fdy. Co.
DABNEY, John C., Jr. ('16; A'24), V. P., Glamorgan Pipe & Fdy. Co.
EATON, C. L. ('30), Timber Lake.
HAMMERSTROM, Wm. G. ('18; '24), Ch. Engr., Lynchburg Fdy. Co.; *for mail*, 819 Pershing Ave.
ROBERTS, Arthur, Jr. (J'36), Ch. Engr., Lynchburg Fdy. Co.
SLOCOMBE, Miss Betty (J'36), 2811 Rivermont Ave.
WILEY, Edgar C. ('03), Cons. Engr., Wiley & Wilson, Peoples Natl. Bank Bldg.
WOOD, Victor L. (J'26), 2024 Rivermont Ave.

MATHEWS COURT HOUSE, Virginia Section

HARDIGG, Jephthah C. ('22; '30), Box 935.

McLEAN, Virginia Section

HAMILTON, Donald (J'36), M. E., Charge Maint. & Tech. Research, Resettlement Admin., Spec. Skills Div., 2216 M St., N. W., Washington, D. C.; *for mail*, Burnside Cottage, McLean, Va.

NEWPORT NEWS, Virginia Section

BAILEY, Chas. Franklin ('22), Engrg. Dir., Newport News Shipbldg. & Dry Dock Co.
BELLINGER, Lorentz D. (J'29), Asst. M. E., Office Superintending Constructor, U. S. N., Newport News Shipbldg. & Dry Dock Co., Newport News; *for mail*, Colony Inn, Hilton Village.
DAVIS, F. C. (J'28), 101—35th St.
DICKERSON, Taliaferro Crawford, Jr. (J'26), Estimator Hyd. Power Sta. Equipment, Newport News Shipbldg. & Dry Dock Co.; *for mail*, 316—56th St.
DREWRY, Thos. W. (J'35), 131—34th St.
FROHMUTH, Robt. Lee (J'36), Electrician's Helper, Newport News Shipbldg. & Drydock Co.; *for mail*, 115—34th St.
IRELAND, Mark L., Jr. (J'28), Draftsman, Newport News Shipbldg. & Dry Dock Co.
JACKSON, Jesse A. (J'28), Tech. Draftsman, Newport News Shipbldg., & Dry Dock Co., Newport News; *for mail*, 314 River Rd., Hilton Village.
LIVEZEY, Walter B. (A'33), Mgr., Dir., Newport News Land Corp.; *for mail*, 4500 Washington Ave.
STERLING, John Carman ('27), Supt., Mch. Shop Div., Newport News Shipbldg. & Dry Dock Co.; *for mail*, 2207 Parrish Ave.
VIA, G. Guy ('30), Supvr. Training, Newport News Shipbldg. & Dry Dock Co.
WRIGHT, Wm. (J'31), Inspr., Newport News Shipbldg. & Dry Dock Co.; *for mail*, 322 Blair Ave.

NORFOLK, Virginia Section

EVANS, Geo. Dorsey (J'33), Asst. Aero. Engr., Design & Testing, Exper. Dept., Naval Air Sta.; *for mail*, Apt. 6, 4911 Newport Ave.
KRONER, Ernest F. ('28 '35), Aero. Engr., Charge Exper. Wk., Naval Air Sta.; *for mail*, 315 Forrest Ave.
LOFSTEDT, Carl J. ('25; '29), Supt., Lone Star Cement Corp., Natl. Bank of Commerce Bldg.; *for mail*, 819 Brandon Ave.
MARTIN, J. A. ('31; '35), Engr., Seaboard Air Line Ry., Norfolk, Va.; *for mail*, 720 St. Marys St., Raleigh, N. C.
OETINGER, Geo., Jr. (J'26), 1502 Royale Park.
PETERSON, S. G. ('32; '35), Shop Engr., Seaboard Air Line Ry., Seaboard Air Line Ry. Bldg.; *for mail*, Apt. H, 3719 Granby St.
PIERCE, Clarence J. ('28), Ch. Engr., S. S. Berwindvale, Staples Coal Co., Transportation Div., 404 Davol St., Fall River, Mass.; *for mail*, 241 E. 40th St., Norfolk, Va.
SCHWEITZER, R. R. ('18; '27), V. P., Gen. Mgr., Layne-Atlantic Co., Layne-Southeastern Co., 633 New Monroe Bldg.

PETERSBURG, Virginia Section

DEWLING, Littell E. ('28; '35; '35), Engr., Solvay Process Co., Hopewell; *for mail*, 1603 Berkeley Ave., Petersburg.
STREET, Lockwood N. ('23; '35), E. E., Design & Constr., Nitrogen Div., Solvay Process Co., Hopewell; *for mail*, 1919 Matoax Ave., Petersburg.

PINEY RIVER, Virginia Section

HETTRICK, A. B. ('34; '35), Ch. Engr., So. Mineral Products Corp.; *for mail*, Piney River, Nelson Co.

POTOMAC, Washington, D. C., Section

McGAHEY, Robt. E. ('21; '35), M. M., Richmond, Fredericksburg & Potomac R. R. Co., Potomac Yard, Potomac; *for mail*, 514 Cameron St., Alexandria.

PULASKI, Virginia Section

JONES, Henry R. (J'31), Inspr., Gen. Chem. Co., 40 Rector St., New York, N. Y.; *for mail*, 27—5th St., Pulaski, Va.

RICHMOND, Virginia Section

BASCOME, Geo. L. ('19), Valuation Engr., Commonwealth of Va., State Corp. Comm.
BUDWELL, Leigh ('16; '21), M. E., Richmond, Fredericksburg & Potomac R. R. Co.; *for mail*, 1600 Confederate Ave.
CALL, A. E. ('17; '20), Mgr., Island Creek Coal Co., 1102 Elec. Bldg.
CARLE, Edw. W. (J'32), Air Conditioning Engr., Carle-Boehling Co., 1641 W. Broad St.; *for mail*, 2220 Floyd Ave.
COOKE, Wm. F. (J'36), 716 Chimborazo Blvd.
COTTY, Wm. O. (J'34), 821 W. 30th St.
COULTER, Ernest B. (J'30), Rayon Div., E. I. du Pont de Nemours & Co.; *for mail*, 25 Libbie Ave.
DAVIS, G. Maslin (J'29), 2005 Evelyn Byrd Rd.
DUNKLE, H. Edw. ('07; '14), Asst. Engr., Solvay Process Co., Hopewell; *for mail*, 1704 South Blvd., Richmond.
FARLEY, Ernst W. ('13), Pres., Richmond Engrg. Co., Inc., 1305 Brook Rd.
FOSTER, Chas. A. B. (J'36), Engrg. Instr., Va. Poly. Inst., 10th & Marshall Sts.
GRAY, Walter A. (J'36), 1604 W. Grace St.
HARRIS, Chas. H. ('21), Gen. Engr., Va. Elec. & Power Co., 7th & Franklin Sts.
HILGARTNER, Geo. H. ('13), Cons. Engr., Export Leaf Tobacco Co., 900 N. Lombardy St.
JOHNSTON, Jas. A. ('07; '21), Partner, M. E. Charge Engrg. Design, Carneal, Johnston & Wright, 809 Elec. Bldg.
KNODEL, Chas. G. (J'23), Project Engr., Spruance Plant, E. I. du Pont de Nemours & Co.; *for mail*, 724 W. 33rd St.
LEE, Wm. Floyd ('07), Engr., Atlantic Life Bldg.
MANNING, C. H. ('35), Maint. of Way Dept., Chesapeake & Ohio Ry.
MILLER, H. C. L., Jr. (J'23), Engr., H. C. L. Miller, Jr., State Planters Bldg.
MOLLESON, Gilbert C. ('27), Div. Engr., Dept. Pub. Wks., Rm. 306, City Hall.
PARRISH, J. Scott ('26), Pres., Richmond Fdy. & Mfg. Co., Inc., Hermitage Rd.
SAVILLE, Allen J. ('20), Pres., Allen J. Saville, Inc., Elec. Bldg.
SCRIVENOR, Arthur ('01), Cons. Engr. & Pat. Atty., 1218 Mutual Bldg.; *for mail*, 1002 West Ave.
SHULTZ, Robt. H. (J'25), Pres., Shultz & James, Inc., 7 N. 6th St.
SMITH, Morris Sparhawk (J'25), Asst. to Mgr., J. R. Johnson & Co., Inc, 2400 Maury St.; *for mail*, 1622 W. Grace St.
STREET, Geo. L., Jr. ('16), Pres. & Gen. Mgr., J. R. Johnson & Co., Inc, 2400 Maury St.
TRAPNELL, Nicholas M. ('28; '35), M. E., Chesapeake & Ohio Ry. Co., 9th & Main St.
WILLIS, Edw. J. ('95; '96), Cons. Engr., P. O. Box 416.

ROANOKE, Virginia Section

GARRETT, Wm. S. (J'22), Mech. Inspr., M. P. Dept., Norfolk & West. Ry. Co.
KORTE, Raymond B. ('21), Draftsman, Charge Checking Mech. Engrg., Norfolk & West. Ry. Co.; *for mail*, Box 501.
LOVETTE, Stanislaus A. ('20; '35), Draftsman, M. P. Dept., Norfolk & West. Ry. Co.; *for mail*, 405 Mountain View Terrace, Virginia Heights.
PILCHER, John A. ('95; '04), M. E., Norfolk & West. Ry. Co.; *for mail*, 436 Walnut Ave., S. W.
ROSS, Wm. T. (J'34), 528 Belleville Rd., Raleigh Court.

SALTVILLE, Virginia Section

DEUTSCH, Zola G. (J'23), Plant Engr., Mathieson Alkali Wks.
LAMB, Hawthorne M. ('17; '35), Appraisal Engr., Mathieson Alkali Wks.; *for mail*, P. O. Box 508.
RUETSCHI, R. R. (J'36).

STAUNTON, Virginia Section

RAYMOND, L. E. ('22; '35), 230 E. Beverly St.

SUFFOLK, Virginia Section

HOPKINS, H. Ray (J'31), M. E., Planters Nut & Chocolate Co.

THEOLOGICAL SEMINARY, Washington, D. C., Section

DE CAZENOVE, Louis A., Jr. ('05; '11), Retired; Theological Seminary, Fairfax Co.

UNIVERSITY, Virginia Section

HESSE, Herman C. (J'28), Assoc. Prof. Engrg. Drawing, Univ. of Va., University; *for mail*, Jefferson Park Ave., Charlottesville.
MACCONOCHIE, Arthur F. ('24; '27), Assoc. Prof. M. E., Engrg. Dept., Univ. of Va.; *for mail*, Rugby Rd.

WAYNESBORO, Virginia Section

EVANS, David Franklin ('16; '25), Dir., Acetate Research, Rayon Dept., E. I. du Pont de Nemours & Co.; *for mail*, 648 Wayne Ave.

WEST FALLS CHURCH, Washington, D. C., Section

LETT, Max A. (J'27), 409 West St.

WASHINGTON

ABERDEEN, Western Washington Section

HILL, Wm. Steinert ('18; '35), Gen. Supt., Grays Harbor Ry. & Light Co., 106 W. Heron St.
LONG, John J. ('19; '25), Pres., Harbor Plywood Corp., Hoquiam; *for mail*, 102 E. 8th St., Aberdeen.
ROSENBAUM, Raymond V. ('28), Res. Engr., Constr. Supt., Sanderson & Porter, Box 918, Aberdeen, Wash.; *for mail*, 524 Fairmont Ave., Fairmont, W. Va.

BELLINGHAM, Western Washington Section

QUACKENBUSH, C. F. ('21; '25; '35), Ch. Engr., Bellingham Diesel Wks., P. O. Box 363.

BREMERTON, Western Washington Section

DAYTON, John Theodore (J'32), Engrg. Draftsman Mech., Puget Sound Navy Yard, Bremerton; *for mail*, 4018—11th Ave., N. E., Seattle.
JOHNSON, Ruben E. ('32), Ch. Draftsman Mchy., Puget Sound Navy Yard.
SHOVAR, Clarence B. ('33), Puget Sound Navy Yard; *for mail*, 704 Summit Ave.

CAMAS, Oregon Section

BAILEY, Geo. D. (J'31), Crown Willamette Paper Co.; *for mail*, 535—2nd St.
CLARKE, Elton B. (J'35), Draftsman, Crown Willamette Paper Co., Camas; *for mail*, 1528—21st Ave., Longview.

CONCRETE, Western Washington Section

STEEN, Sigurd (J'32), Electrician, Elec. & Mech. Maint., Puget Sound Power & Light Co., Elec. Bldg., Seattle; *for mail*, Concrete.

COULEE DAM, Inland Empire Section

HOECH, Lester W. (J'35), Inspr., Concrete Control, U. S. Bur. of Reclamation; *for mail*, Box 355.
KARTINEN, Ernest (J'35), Engr., U. S. Bur. of Reclamation; *for mail*, Box 146.
MANN, Theo. E. (J'32), Inspr., Concrete Control, U. S. Bur. of Reclamation; *for mail*, Box 45.
MESSER, Rowland E. (J'36).
MOORE, Alfred F. (J'35), Box 368.

ELMA, Western Washington Section

MURRAY, Chas. P. (J'33).

EVERETT, Western Washington Section

FLATEBOE, E. I. ('14; '35), Gen. Mgr., Summer Iron Wks.; *for mail*, 1025 Wetmore Ave.
McCARTHY, Justin H. ('22; '35), c/o Soundview Pulp Co.

HARPER, Western Washington Section

PETHERICK, Robt. L. (J'35).

HOQUIAM, Western Washington Section

ANDERSON, Aubrey E. (J'35), 302 K St.
LUCEY, Wm. S. ('15; '22), V. P., Grays Harbor Corp. & Gen. Mgr., Grays Harbor Pulp & Paper Co.

LONGVIEW, Western Washington Section

HUFFMAN, Chas. A. ('24), Constr. Engr., Long Bell Lumber Co.; *for mail*, 1428—25th St.
SUTHERLING, Virgil M. (J'34), Asst. Process Engr., Longview Fibre Co., Longview; *for mail*, Route 2, Kelso.
WOLF, Robert B. ('13; F'36), Vice-President, '20-'22; Mgr., Pulp Div., Weyerhaeuser Timber Co.

OLYMPIA, Western Washington Section

JAKUBOVSKY, J. Howard (J'32), Foreman, Plywood Dept., Henry McCleary Timber Co., McCleary; *for mail,* 727 West Bay Dr., Olympia.

PORT LUDLOW, Western Washington Section

MILLER, Roy R. (J'33).

PORT TOWNSEND, Western Washington Section

BROWN, Wallace M. (J'36), 1406 Garfield St.

PULLMAN, Inland Empire Section

CANDEE, Frank W. ('26; '35), Assoc. Prof. M. E., State College of Wash.
CARLSON, Alf H. (J'35), U S. Soil Conservation Serv., Dept. of Agri., Pullman; *for mail,* W. [illegible] Ave., Spokane.
CARPENTER, Hubert V. ('17), Dean, College of Mech. Arts & Engrg., State College of Wash.; *for mail,* 300 Oak St.
LANGDON, Howard H. ('25; '35), Prof., Head Dept. M. E., State College of Wash.; *for mail,* 210 Pioneer Way.
PARKER, Prof. E. B. ('34), Assoc. Prof. M. E., State College of Wash.; *for mail,* 207 College Ave.
TEWINKEL, G. Carper (J'33), 508 McKenzie St.

SEATTLE, Western Washington Section

ADAMS, Harold L. (J'30), *Student Award,* '30; Stress Engr., Boeing Airplane Co., 200 W. Michigan St.; *for mail,* 2308—44th Ave., S. W.
AITKEN, Murray (J'33), Designer, Draftsman, Kenworth Motor Truck Corp., Yale & Mercer Sts.; *for mail,* 3412—61st Ave., S. W.
BARTHOLET, Donnell F. (J'33), Sales, Fairbanks, Morse & Co., 1226—1st Ave., S.; *for mail,* 403 Terry St.
BEGGS, Wm. E. ('29), Owner, W. E. Beggs Co., 907 Lloyd Bldg.; *for mail,* 3639 Palatine Ave.
BERGER, Knute ('26), Pres. & Gen. Mgr., Berger Engrg. Wks., Inc., 3236-40—16th Ave., S. W.; *for mail,* 3432 Mt. Baker Blvd.
BLIVEN, Paul (J'34), Pat. Lawyer, 1302 Hoge Bldg.
BOWEN, Harry S. ('31; '35), V. P., Puget Sound Sheet Metal Wks., 3631 E. Marginal Way.
BROWNING, Frank H. ('14), Engr. Examiner, City of Seattle, Civil Serv. Comm.; *for mail,* 1514—35th Ave.
CLAUSEN, Jensen C. (J'30), Foreman, Am. Can Co., Elliot & Vine St.; *for mail,* 6220—28th St., N. E.
CRUIKSHANK, Barton ('89), Mgr., Cruikshank Engrg. Co., 909—4th Ave.
CURTIS, Leon D. (J'35), 4217—2nd Ave., N. E.
DORSEY, Geo. P. (J'35), Draftsman, Steel & Concrete Structures, Dept. Fisheries, State of Washington, 707 Lloyd Bldg.; *for mail,* 5727—17th St., N. E.
DUDLEY, Wm. L. ('21) Manager, '35-'38; V. P., Charge Design & Sales, West. Blower Co., Westwind Corp., 1800 Airport Way; *for mail,* 814—32nd Ave.
DYE, Ira W. ('13; '35), Supvr., Pac. Coast Staff Engrs., Geo. S. May Co., 2600 N. Shore Ave., Chicago, Ill.; *for mail,* 5950—32nd Ave. S., Seattle, Wash.
DYER, R. L. ('31; '35), Sales Engr., Natl. Bank of Commerce Bldg.
EASTWOOD, Everett O. (14; F'36), Manager, '23-'26; Vice-President, '26-'28; Prof. M. E., Univ. of Wash.
EDMONDS, Robt. H. G. ('24; '30), Asst. Prof. M. E., Univ. of Wash.
FLOODEEN, Eddy ('24; '35), M. & E. E., Lloyd Bldg.
FORD, Harold P. ('24), Mech. Designer, U. S. Engrs., 627 Pittock Block, Portland, Ore.; *for mail,* 3312 Empire Way, Seattle Wash.
GIBSON, Wm. Robt. ('30), Engr. Sales, Shibley Co., 1201 Textile Tower.
GREAVES, Fred G. ('25; '35), Propr., Sales Engr., Fred G. Greaves Co., 400 Polson Bldg.; *for* mail, 4519—7th Ave., N. E.
HARRIS, David W. (J'35), Sales Engr., C. C. Moore & Co., Engrs., 1916 Smith Tower; *for mail,* Apt. 107, 1619 Belmont Ave.
HARRIS, Ernest N. ('21; '35), 1810 Bigelow Ave., N.
HARTMAN, L. G. ('36), Engr., Charge Power House Opera. & Maint., Seattle Cedar Lumber Mfg. Co., 1540 W. 46th St.; *for mail,* 8528—31, N. W.
HEFFERNAN, John T. ('94), Pres., Glacier Gravel Co., 2101 Northern Life Tower.
HUTTON, S. E. ('12), 1542—17th Ave., N.
JACKSON, Dean B. ('24; '25; '35), Ch. Engr., Charge Design & Serv., Jenkins Engrg. Co., 518 Virginia.
JOHNSON, Philip G. ('22; '35), V. P., Charge Mfg., Kenworth Motor Truck Corp., 1263 Mercer St., Seattle; *for mail,* Rt. 1, Box 10, Edmonds.
JOHNSTONE, Chas. A. (J'34), 1816—8th Ave., W.
KAY, Roy H. (J'35), 1316 E. 68th St.
KIRSTEN, Frederick K. ('29), Prof. Aero. Engrg., Univ. of Wash.
KRUEGER, Geo. H. ('18; '21; '30), Cons. M. E., 8823—47th Ave., N. E.
LEE, Fairman B. ('21; '30; '35), Owner, Fairman B. Lee, Power & Elec. Products, 305—1st Ave., S.
LOCKWOOD, Jas. B. C. ('16), Cons. Engr., 1632—17th Ave.
LOWRY, Edmund G. (J'36), 1019 Terry.
MANN, Carl P. ('16; '23), Secy., Treas., A. Kristoferson, Inc., 1300 Rainier Ave.; *for mail,* 230—35th Ave., N.
MARDEN, Jack S. (J'33), Dispatcher of Serv. Crews, Puget Sound Power & Light Co., 7th & Olive St.; *for mail,* 3027—59th St., S. W.
McCULLOUGH, Jos., Jr. (J'35), 927—20th North.
McINTOSH, Wm. J. ('36), M. E., Charge Applications, Sales, Fairbanks, Morse & Co., 1226—1st Ave., S.; *for mail,* 2811—32nd Ave., S.
McINTYRE, Harry J. ('27; '30), Assoc. Prof. M. E., Univ. of Wash.
McMINN, Bryan T. ('21; '28), Asst. Prof. M. E., Univ. of Wash.
McPHERSON, W. J. ('33), M. E., Asst. Bldg. Engr., Pac. Tel. & Tel. Co., Seattle; *for mail,* 807 S. 18th Ave., Yakima.
MERO, Ralph M. ('25; '30), Ch Engr., Troyer Fox Plant, Continental Can Co., Inc., 601 Myrtle St.; *for mail,* 3618 Viewmont Way.
MOFFITT, Robt. C. ('25; '32), Pres., Thunderbird Mines, Ltd., N. P. L., Invermere, B. C., Can.; *for mail,* P. O. Box 743, Seattle, Wash.
MORITZ, Harold K. (J'21), Instr., Dept. Gen. Engrg., Education Hall, Univ. of Wash.
MORRIS, John K. (J'35), Engr., West. Gear Wks., 9th Ave. & King St.; *for mail,* 741 Federal Ave.
MYLROIE, John E. (J'36), Htg. Engr., West. Furnace Co., 3002-20 S. Chandler St., Tacoma; *for mail,* 1421—20th Ave., Seattle.
NEFF, Jack I. (J'32), Draftsman, Continental Can Co., 601 Myrtle St.; *for mail,* 2810—16th Ave., S.
NEWELL, Wallace L. ('14), Cons. M. E., 1315 Alaska Bldg.
NEWSTROM, Carl L. (J'32), Senior Engrg. Draftsman, Puget Sound Navy Yard, Bremerton; *for mail,* 5720—37th St., N. E., Seattle.
NIKAZY, Chas. N. (J'35), c/o Quinten Somera, 120 W. Highland Dr.
NOLAN, Clarence C. (J'36), Engr. on New Constr. Wk., St. Paul & Tacoma Lumber Co., Tacoma; *for mail,* 7502 Latona Ave., Seattle.
O'LEARY, Daniel ('14), Salesman, Wire Rope Mfg. & Equip. Co., 121 W. Massachusetts St.; *for mail,* 208 Queen Ann Ave.
OSTRAND, Lieut. Jas. A., Jr. (J'33), *Post Graduate Student Award,* '33; Ft. Lawton.
PATERSON, James V. ('12), 1025 Boylston Ave., N.
PETERS, Herbert E. ('25; '30), Inspr. Boilers, U. S. Bur. of Mar. Inspc. & Navigation, 603 Federal Office Bldg.
REASER, Wilbur W. (J'36), Template Layout, Boeing Aircraft Co., Youngstown Station; *for mail,* 4310½ W. Raymond St.
RHODES, Fred H., Jr. ('26; '32; '35), Instr., Civil Engrg. Dept., Univ. of Washington; *for mail,* 2828—43d St., W.
ROCKAFIELD, Neil Lewis (J'35), 1415 E. Olive St.
ROCKWELL, Robt. L. ('23), Cons. Engr., Suite 802 Alaska Bldg.
SCHAAL, Norbert J. ('25; '35), Engr., Charge Design, C. M. Lovsted & Co., Inc., 2214 1st Ave., S.; *for mail,* Rt. 9, Box 801.
STEVENS, Walter O. (J'27), Cons. Engr., 612—15th Ave., N.
STITH, Richard L. (J'31), *Student Award,* '30; Stress Engr., Boeing Airplane Co., 200 W. Michigan St.; *for mail,* 4124 Meridan Ave.
SUMNER, Henry W. ('00; '12), University Club.
VAN RY, Wm. H. (J'36), 1111 Boylston.
VOSSBRINCK, Wm. J. H. (J'34), Sales Engr., Chicago Pneumatic Tool Co., 6 E. 44th St., New York, N. Y.; *for mail,* 2415 E. Boston St., Seattle, Wash.
WALLACE, Wm. Adam (J'28), Sales Engr., Prescott Iron Wks., 1 W. Lander St.; *for mail,* 6540 Fauntleroy Ave.
WALSH, Jos. ('36), Walsh Constr. Co., Ltd., 1252—1st Ave., S.
WALTER, Ralph ('28; '35), Engr., Charge Sales Promotion, Fisher Flouring Mills Co., Harbor Island; *for mail,* 5261—11th Ave., N. E.
WATNEY, J. R. (J'33), Jr. Engr., Boeing Aircraft Co.; *for mail,* 1818—20th Ave.
WATT, John Reid (J'36), 1306 Madison St.
WHITE, Elmer J. (J'23), Engr., Charge Design & Constr., MacRae Bros., 614—5th Ave.; *for mail,* 3332—43rd Ave., N. E.
WILSON, Geo. Samuel ('07; '14), Prof. M. E., Univ. of Wash.
WINSLOW, Arthur M. ('21), Prof. M. E., Univ. of Wash.
YOST, Chas. J., Jr. ('23; '34; '35), Factory Rep., 603 Lloyd Bldg.

SPOKANE, Inland Empire Section

CARPENTER, Chas. I. ('12; '23), Arch., Engr., 1516 Old Natl. Bank Bldg.
GRAF, Ervin W. (J'32), E. 2105—3rd Ave.
GRAY, David R. ('30; '36), M. E., Charge Maint., Diamond Watch Co., Box 15.
HOBERG, B. Norman (J'34), 512 W. Maxwell Ave.
JONASSON, Carl Wm. (J'35), Elec. Helper Apprentice, Maint. of Air Conditioning, Pullman Co., No. Pac. Depot; *for mail,* E. 1633 Providence.
KARLSTEN, Albert Royal (J'31), M. E., Washington Water Power Co., W. 825 Trent Ave.; *for mail,* W. 1707 Pacific Ave.
KEMMISH, L. W. (J'35), N. 5915 Monroe St.
LINDSAY, Alex. ('20), Supt. Water, City of Spokane, City Hall.
MacCAMY, Harry Jas. ('21; '35), Ch. Engr., Union Iron Wks.; *for mail,* 2124 W. Maxwell Ave.
MORRISON, Walter B. (J'35), Air Conditioning Engr., Jas. Smyth, Inc., 90 Sprague W., Spokane, Wash.; *for mail,* 1806 N. E. 27th Ave., Portland, Ore.
POSPISIL, Louis J. ('20), M. E., Washington Water Power Co.; *for mail,* W. 103 17th Ave.

TACOMA, Western Washington Section

ANDERSON, Geo. Wm. (J'32), Route 4, Box 715.
CHRISTIE, E. W. ('90), 2907 S. 9th St.
WALSTAD, Adolph N. ('21), Prop., Walstad Mch. Co., 910-912 Tacoma Ave.
WHITE, Hosea O. (J'32), Asst. Engr., Consumers Cent. Htg. Co., 106 E. 11th St.; *for mail,* Triona Apts., 7th & Yahama.

WENATCHEE, Western Washington Section

MOORE, Roy Allen (J'35), Class C Machinist, Puget Sound Power & Light Co. of Seattle, Route 5, Wenatchee; *for mail,* Rock Island.

WEST VIRGINIA

ALLOY

WOOD, Ernest P. (J'31), Engr., Charge Power Sta., Power Dept., Electro Metallurgical Co.

BAKERTON

HETZEL, Lowell H. (J'34), M. E., Plant Control, Washington Bldg., Lime Co.; *for mail,* Box 73.

BLUEFIELD, West Virginia Section

WALKER, Robt. Emmons (J'36), M. E., Charge Air Conditioning Installations & Design, Barlow-Wisler, 1238 S. Bland St.; *for mail,* 2025 Washington St.

CABIN CREEK, West Virginia Section

HUDSON, Edw. L. ('24; '35), Prod. Supt., Appalachian Elec. Power Co.
MAY, David H. (J'29), Pure Oil Co.
SCHMARJE, Clarence F. (J'33), Results Engr., Appalachian Elec. Power Co.

CAMERON, Pittsburgh Section

MONROE, Edwin T. (J'33), V. P., Cameron Tool & Supply Co.

CHARLESTON, West Virginia Section

ALLSPACH, Homer E. (J'35), Prod. Foreman, M. E., Carbide & Carbon Chems. Corp., S. Charleston; *for mail,* 611½ Grant St., Charleston.
ARCHER, C. E. (J'36), 412 Morris St.
BAKER, Hiram Maxfield ('29), United Fuel Gas Co., P. O. Box 1256.
BLOOMSBURG, Marvin S. (J'27), M. E., E. I. du Pont de Nemours & Co., Belle; *for mail,* 1424 Quarrier St., Charleston.
FORTNEY, C. P. ('13; '16), Cons. Engr., 208 Union Bldg.
FOX, Raymond W. ('24; '27; '35), Power Engr., Ammonia Div., Belle Wks., E. I. du Pont de Nemours & Co., 2007 Quarrier St.
GEOGHEGAN, Wm. H. B. (J'36), Test Engr., Carbide & Carbon Chems. Co., 30 E. 42nd St., New York, N. Y.; *for mail,* Box 315, Charleston, W. Va.
HABICHT, Ernest R. ('26; '34; '35), Asst. Mech. Supt., Process Div., E. I. du Pont de Nemours & Co., Belle; *for mail,* 105 Bradford St., Charleston.
JOHNSON, Chas. Lewis (J'30), Asst., Pub. Serv. Comm. of W. Va.; *for mail,* 1204 Kanawha St.
KEENAN, Walter Francis, 3rd (J'36), M. E. Carbide & Carbon Chems. Corp., S. Charleston; *for mail,* 1559 Virginia St., Charleston.
MORGAN, John T. ('12; '19; '25), Secy., Sales Mgr., Charleston Elec. Supply Co., 914 Kanawha St.; *for mail,* 1538 Quarrier St.
PLOVANICH, John P. (J'32), 604 Randolph St.

POTTER, James H. (J'36), Jr. Engr., E. I. du Pont de Nemours & Co., Belle; *for mail*, 2030 Kanawha St., Charleston.
SCHAEFER, F. LeRoy ('33), Div. Engr., E. I. du Pont de Nemours & Co.; *for mail*, Oakwood Dr., R. F. D. 2.
SHAW, Harold W. (J'35), M. E., Process Safety Dept., Carbide & Carbon Chems. Corp., S. Charleston; *for mail*, Box 940, Charleston.
SHEDD, Fred R. ('31; '35), Results Engr., Appalachian Elec. Power Co., 301 Virginia St.
STAFFORD, Wm. H. (J'35), 1573 Lee St.
THOMPSON, Dexter M. (J'34), Engr. Supvg., Constr. & Maint., Belle Wks., E. I. du Pont de Nemours & Co., P. O. Box 1537; *for mail*, 2106-A Kanawha St.
TINKER, Jas. B. (J'30), M. E., Tech. Dept., E. I. du Pont de Nemours & Co.
WARD, Chas. E. ('00), Pres., Chas. Ward Engrg. Wks., P. O. Box 647.

CLARKSBURG, Pittsburgh Section
BONSALL, Judson ('27; '35), Supt. Compressing Stas., Equitable Gas Co., also Pittsburgh & W. Va. Gas Co., Union Bank Bldg.
BRADY, Hugh S. ('18; '23), Treas., Hart Bros. Mach. Co.
CROWTHER, J. G. ('26), Supvr., Mchy., Hope Natural Gas Co., Clarksburg; *for mail*, P. O. Box 370, Salem.
MAYFIELD, Wm. W. (J'35), Cadet Engr. (M.E.), Hope Natural Gas Co.; *for mail*, 205 Carpenter St.
McKINLEY, Geo. W. (J'34), M. E., Hope Natural Gas Co., Main St.; *for mail*, 206 N. Chestnut St.
VARADY, John C. ('36), Wks. Engr., Natl. Carbon Co., Inc.

EAST CHARLESTON, West Virginia Section
YOUNG, John H., Jr. ('16; '21), Lub. Engr., Stand. Oil Co. of N. J., Charleston; *for mail*, 1556-A Virginia St., E. Charleston.

FAIRMONT, Pittsburgh Section
DRAKE, Wm. V. ('27; '35), Mgr., Power Generation, Monongahela West Penn Pub. Serv. Co., Watson Bldg.; *for mail*, 1204 Locust Ave.
DUNCAN, C. A. ('29), Constr. Supt., Sanderson & Porter, P. O. Box 1192.
RIBLETT, Guy H. ('25), Ch. Engr., Fairmont Min. Mchy. Co.; *for mail*, P. O. Box 969.

GARY, West Virginia Section
SCHICKEDANZ, L. H. (J'16), Engr., U. S. Coal & Coke Co.; *for mail*, P. O. Box 158.

GLENDALE, Pittsburgh Section
HECKERS, Wm. (J'30), Louis Marx & Co.

GLEN FERRIS, West Virginia Section
HILL, Andrew (J'25), Designing Engr., Power Dept., Electro-Metal Co.
MALLOY, John F. ('24; '33), Designer, Power Dept., Electro-Metal Co.

HUNTINGTON, West Virginia Section
ALCOTT, E. A. (J'35), 1205—1st St.
BROOKE, Minott ('35), Asst. Fuel Serv. Engr., Chesapeake & Ohio Ry. Co., Richmond, Va.; *for mail*, 1010—12th Ave., Huntington, W. Va.
DILCHER, H. S. ('21; '35), Acting Dist. Engr., 5th W. Va. Dist., Wks. Progress Admin., Homrich Bldg.; *for mail*, 532—6th Ave.
FEYLING, Gerhard T. (J'35), Draftsman, Internatl. Nickel Co., Inc.; *for mail*, R. F. D. 4.
HAECKER, John H. (J'33), Metallurgist, Internatl. Nickel Co., Inc.; *for mail*, Pea Ridge Rd.
OELKERS, Albert L. (J'27), Draftsman, U. S. Engrs., C. & O. Bldg.; *for mail*, P. O. Box 921.
REGGEL, Walter G. A. (J'35), Engr., Huntington Wks., Internatl. Nickel Co., Inc.
WILSON, Ralph Norton (J'36), 1134—9th Ave.

KEYSTONE, West Virginia Section
RIPLEY, F. D. (J'36), Asst. Foreman, Norfolk & West. Ry., Eckman Shop, Eckman; *for mail*, P. O. Box 67, Keystone.

LARGENT
DONNELLY, Jas. A. ('11).

LEWISBURG, West Virginia Section
POLE, Lanier A. (J'36).

LOGAN, West Virginia Section
LUGRIN, Prosper ('29), Plant Supt., Appalachian Elec. Power Co.

MONTGOMERY, West Virginia Section
SKAAGS, Henry C., Jr. (J'36), 602—3rd St.

MORGANTOWN, Pittsburgh Section
AMIDON, Lee L. ('28; '34; '35), Asst. Prof. Power Engrg., W. Va. Univ.; *for mail*, 91 Grandview Ave.
HAYES, Leslie David ('19), Prof. Mch. Design & Constr., W. Va. Univ.; *for mail*, 804 College Ave.
JONES, Clement R. ('98; '01), Dean College Engrg., & Prof. Power Engrg., W. Va. Univ., Box 851.

OMAR, West Virginia Section
HELT, Wilbur C. (J'35), Jr. Engr., W. Va. Coal & Coke Corp.; *for mail*, Box 362.

PIEDMONT
JONES, Saml. B. ('24), Research Engr., W. Va. Pulp & Paper Co.

POINT PLEASANT, West Virginia Section
ADIE, Jas. A. ('23; '35), Designer, Marietta Mfg. Co.; *for mail*, 1001 Viand St.
WEISSENBURGER, C. O. ('20), Pres., Marietta Mfg. Co., P. O. Box 17.

POWER, Pittsburgh Section
FRANKENBERG, Theo. T. (J'34), Test Engr., Beech Bottom Power Co.; *for mail*, Clubhouse.

RIVESVILLE
DANIELS, Daniel V. (J'36), Piping Layout Designer, Sanderson & Porter Co.

SOUTH CHARLESTON
CARSPECKEN, Henry L., Jr. (J'34), Design & Engrg. Dept., Carbide & Carbon Chems. Corp., S. Charleston; *for mail*, 5 Buena Vista Pl., Charleston.
HICKMAN, H. B. (J'34), Scheduling Engr., Carbide & Carbon Chems. Corp., S. Charleston; *for mail*, 200 Main Dr., Charleston.
HICKOX, Chas. M. ('29; '35), Supvr., Steam Div., Constr. Engrg. Dept., Carbide & Carbon Chems. Corp.; *for mail*, 505 Montrose Dr.
LANGE, Otto C. ('31), M. E., Carbide & Carbon Chems. Corp., S. Charleston; *for mail*, 1591-D Jackson St., Charleston.
MILLER, Jos. F. G. (J'35), M. E., Carbide & Carbon Chems. Corp.; *for mail*, 124—2nd Ave.
WELCH, Nicholas Anthony (J'36), Test Engr., Carbide & Carbon Chems. Corp.; *for mail*, 7 W. 8th Ave.

WEIRTON, West Virginia Section
MUNNS, John J. ('28), Asst. V. P., Weirton Steel Co.

WELCH, West Virginia Section
PIKE, Reginald (J'32), Refrig. Salesman, Jones Cornett Elec. Co.; *for mail*, Box 546.

WHEELING, Pittsburgh Section
CHAFFIN, Warren L. ('29; '35), Mgr., Charge Factory, J. L. Stifel & Sons, Inc., 339 Main St.
FOSS, Feodore F. ('21), Gen. Metallurgist, Wheeling Steel Corp.
KAYLOR, Jacob H. (J'22), Engrg. Dept., Hazel-Atlas Glass Co., 15th & Jacob Sts.
MEHARG, Laurence ('12; '17; '20), Ch. Engr., Hazel-Atlas Glass Co., 15th & Jacob Sts.; *for mail*, 36 Rockledge Rd.
STRIDER, I. H. (AM'33), Hazel-Atlas Glass Co.

WISCONSIN

ALBANY
WOOD, John M. ('17; '22; '27), Mgr., Treas., Albany Hardware Spec. Mfg. Co., Inc., 536-538 Water St.; *for mail*, P. O. Box 312.

APPLETON, Milwaukee Section
FANNON, Wm. A. ('07), Pres., Treas., Fannon Trading Co., P. O. Box 454, 844 E. Alton St.
FEMAL, Ernest J. (J'26; '35), Pres., Mgr., Fox River Boiler Wks.; *for mail*, 703 S. Story St.
JILEK, Otto F. (J'29), Mch. Designer, Valley Iron Wks. Co., S. Island St.; *for mail*, 521 E. McKinley St.
PAULSON, Peter A. ('15), Cons. Engr., 1712 S. Mason St., Drawer 259.
SCHUBERT, Wm. E. ('21; '25; '29), Gen. Mgr., Wis. Mch. Power Co., 112 College St.; *for mail*, 213 Prospect St.

BELOIT, Rock River Valley Section
BALDWIN, F. K. (J'29), Diesel Engrg., Fairbanks, Morse & Co.; *for mail*, 1251 Eaton Ave.
BRUCKNER, Robt. E. (J'25), Asst. to Chief Engr., Fairbanks, Morse & Co.; *for mail*, 1011 Bushnell St.
BUTTERFIELD, Alan Gardner (J'35), Research Engr., Fairbanks, Morse & Co.
BYLL, Alan John (J'35), Fairbanks, Morse & Co., Beloit; *for mail*, 1124 W. Johnson St., Madison.
DAHLUND, Ervin L. (J'35), Designing Engr., Fairbanks, Morse & Co.; *for mail*, 526 St. Lawrence.
DUNDORE, Marvin Walter (A'26), Prod. Mgr., Beloit Iron Wks.
GLAZEBROOK, R. C. (J'32), Hyd. Engr., Fairbanks, Morse & Co., Lawton Ave.; *for mail*, 613 Milwaukee Rd.
GRUTZNER, F. P. ('23), Asst. Ch. Engr., Diesel Eng. Div., Fairbanks, Morse & Co.; *for mail*, 1133 Milwaukee Rd.
HALL, Harry ('26; '32; '35), Div. Engr., Charge O. P. Diesel Div., Fairbanks, Morse & Co.; *for mail*, 846 E. Grand Ave.
HENRY, Scott L. (J'36), Fuel Oil & Lub. Oil Tester, Fairbanks, Morse & Co.; *for mail*, 1324 Chapin St.
HESSELLUND, Regnar (J'30), Asst. Engr. Charge Field Serv., Fairbanks, Morse & Co.; *for mail*, 1327 White Ave.
HOBART, Frank G. ('90), Cons. Engr., Fairbanks, Morse & Co.; *for mail*, 732 Hobart Pl.
HUGLE, Herman ('21; '35), Designer, Beloit Iron Wks.; *for mail*, 651 Milwaukee Rd.
JACKSON, Lawrence B. ('18), Mgr. Engrg., Fairbanks, Morse & Co.
JUSTUS, J. E. ('35; '35), Serv. Engr., Fairbanks, Morse & Co.; *for mail*, 1220 LaSalle St.
MACKLEM, Geo. A. ('17), V. P., Charge Sales, Beloit Iron Wks.
MACNEILLE, Martin B. ('21), Ch. Engr., Hyd. & Dealer Prods., Fairbanks, Morse & Co.; *for mail*, 1747 Sherwood Dr.
MEEK, Geo. W. (J'32), Devel. & Sales Engr., Gen. Refrigeration; *for mail*, 737 Park Ave.
OWENS, Jas. Whitfield ('29), Director of Welding, Fairbanks, Morse & Co.
REINERTSON, Jos. H. (J'36), Instrument Man, Fairbanks, Morse & Co.; *for mail*, 1324 Chapin St.
SCHRECK, H. ('14), Asst. Ch. Engr., Charge Design, Fairbanks, Morse & Co.; *for mail*, 1208 Chapin St.
SMITH, John M. ('18; '26), M. E., Yates Am. Mch. Co.; *for mail*, 714 Kenwood Ave.
SMITH, Ronald R. ('28; AM'35), Draftsman, Beloit Iron Wks., Beloit; *for mail*, 617 Prospect Ave., Janesville.
VAN METER, Homer (J'32), Exper. Tester, Exper. & Research Dept., Diesel Div., Fairbanks, Morse & Co.; *for mail*, 904½ Oak St.
WILLIAMS, Richard A. ('30), Engr., Yates-Am. Mch. Co.; *for mail*, 1275 Central Ave.

EAU CLAIRE
HUTCHENS, Ralph W. ('18; '26), V. P. & Mgr., Gillette Rubber Co.

FOND DU LAC
KRAUT, Hans B. ('16), Pres., Gen. Mgr., Giddings & Lewis Mch. Tool Co., 142 Doty St.; *for mail*, 15 S. Park Ave.

FORT ATKINSON, Milwaukee Section
SHODRON, John G. ('08; '21), Cons. Engr., Research, James Mfg. Co.; *for mail*, 411 E. Milwaukee Ave.
SWEET, Franklin ('03; '13), Estimating Engr., Creamery Package Mfg. Co.; *for mail*, 500 S. Main St.

GREEN BAY
BLAKE, Thos. Walter (J'29), M. E., No. Paper Mills; *for mail*, 604 S. Jackson St.
KIRKBY, T. M. ('23), Supt. Motive Power & Equip., Norwood Shops, Green Bay & Western Lines; *for mail*, 1001 S. Webster.
KOWALESKI, Wm. C. ('31; '35), Engr., No. Paper Mills; *for mail*, 420 Harvard St.

KENOSHA, Milwaukee Section
CHAFFE, Wm. H. ('22), M. E., Charge Power Plant, Simmons Co.; *for mail*, 7617—6th Ave.

LA CROSSE
ANDEREGG, R. H. ('20; '25; '35), Trane Co.; *for mail*, 324 N. 24th St.
FUNK, Wm. F. ('92; '05), Pres. Mgr., LaCrosse Boiler Co., 418 Gould St.

LA POINTE
TRULSON, Arthur F. (J'26),

MADISON
BREIBY, Norman H. (J'30), 149 Jackson St.
COLBERT, Thos. P. ('26; '35), Instr., Mch. Design, M. E. Bldg., Univ. of Wis.
ELLIOTT, Ben. G. ('11; '16; '23), Prof. M. E., Univ. of Wis.; *for mail*, 2302 Commonwealth Ave.

HARTENBERG, Richard S. (J'28), Instr., Dept. of Mechanics, Univ. of Wis.; *for mail*, 40 Roby Rd.
HEEBINK, Bruce G. (J'32), Engr., Forest Products Lab.
JOHNSON, Hobart S. ('06), Pres., Gisholt Mch. Co.
LARSON, G. L. ('15), Chmn. Dept. M. E., Univ. of Wis., M. E. Bldg.
LAUSCHE, Luverne F. (J'36), Engr., Savidusky's Inc., 315 N. Few St.
LINDE, G. F. ('28; '35), Supt., Scanlan-Morris Co.; *for mail*, 306 N. 6th St.
MATHEWSON, Jas. S. ('15; '25), Asst. in Charge Sec. of Timber Physics, Forest Products Lab., Highland Ave.
MAURER, Edw. R. ('30), Prof. Mechanics, Univ. of Wis.; *for mail*, 167 N. Prospect Ave.
MEAD, Daniel W. ('08), Cons. Engr., Mead, Ward & Hunt, State Journal Bldg.
NELSON, D. W. ('23; '30), Asst. Prof., Steam & Gas Engrg., M. E. Bldg., Univ. of Wis.
ROSE, Reed A. ('21; '30), Asst. Prof., Steam & Gas Engrg., M. E. Bldg., Univ. of Wis.
SENGER, Werner I. (J'23), M. E., Gisholt Mch. Co.; *for mail*, 1806 Rutledge St.
WHITE, John C. ('06; '11), State Power Plant Engr., Power Plant Div., State Bur. of Engrg., 624 E. Main St.
WILSON, Grover C. ('25), Assoc. Prof., Steam & Gas Lab., Univ. of Wis., M. E. Bldg., University Ave.; *for mail*, 1421 Vilas Ave.
WILSON, L. A. ('17; '22), Assoc. Prof., M. E. Bldg., Univ. of Wis.

MANITOWOC

CANNARD, Richard E. (J'35), Effic. Engr., Wis. Pub. Serv. Corp.; *for mail*, 1035 N. 14th St.
KRATSCH, A. E. ('29; AM'35), Ch. Engr., Curt G. Joa, Inc.; *for mail*, 529 S. 30th St.
WEST, John D. (J'32), Mch. Shop Gen. Foreman, Manitowoc Shipbldg. Corp.; *for mail*, Route 2.

MENASHA

GREINER, Chas. J. ('32; '35), Devel. Engr., Kimberly Clark Corp., Neenah; *for mail*, 813 Manitowoc St., Menasha.

MILWAUKEE, Milwaukee Section

ALLEN, Wyeth ('29), Cons. Engr., 161 W. Wisconsin Ave.
ANDREWS, Edw. Vail ('20), Sales Engr., Nordberg Mfg. Co.; *for mail*, 2853 S. Mabbett Ave.
ASMUSSEN, Jes (J'27), Engr., Charge Testing Dept., A. O. Smith Corp., 3533 N. 27th St.; *for mail*, 2106 W. Vienna Ave.
AVEY, Harry T. ('18), Assoc. Prof. M. E., Ext. Div., Univ. of Wis., 623 W. State St.; *for mail*, 2729 N. Stowell Ave.
BECK, Matthias A. ('86), Retired; 3070 S. Superior St.
BEMM, Harold F. (J'36), Engr., Durant Mfg. Co., 1929 N. Buffum St.; *for mail*, 2751 N. Prospect Ave.
BILTY, C. H. ('33), M. E. Design, Milwaukee Shops, Chicago, Milwaukee, St. Paul & Pacific R. R. Co.; *for mail*, 1008 N. 39th St.
BLISS, Wm. D. ('20), Pres., Bliss Bros. Tool Co., 1736 N. 2nd St.
BLOCKER, Henry A., Jr. (J'28), Appraisal Engr., Am. Appraisal Co., 525 E. Michigan St., Milwaukee, Wis; *for mail*, 3961—50th St., Woodside, L. I., N. Y.
BOEHCK, Richard E. ('22; '35), Pres., Gen. Mgr., Boehck Mchy. Co., Inc., 2404 Clybourn St.
BOENING, F. S. ('31), Designer, Falk Corp.; *for mail*, 2369 N. 40th St.
BORMANN, Henry R. ('24; '35), Sales Engr., Krenz & Co., 5114 W. Center St.; *for mail*, 1303 N. 54th St.
BORN, John E. (J'35), 3117 W. Highland Blvd.
BOSSERT, Chas. P. ('92; '01), Retired; 727 N. 37th St.
BRADLEY, Harry L. ('21; '35), V. P., Treas., Allen Bradley Co., 1326 S. 2nd St.
BROWER, Jas. ('25), Supt. & M. E., Milwaukee Sewage Comm., Jones Island; *for mail*, 3021 N. 36 St.
BRYCE, Jas. ('31; '35), Engr., Inspec. Div., Md. Casualty Co., Rm. 400, 611 N. Broadway.
CAHILL, Chas. A. ('18), Cons. Engr., Mgr., Chas. A. Cahill & Sons, 724 Mason St.
CALDWELL, Eugene ('28; '33), Gen. Mgr., Wrought Washer Mfg. Co., 2100 S. Bay St.; *for mail*, 4447 N. Cramer Ave.
CAMPBELL, Maver J. (J'31), Engr., Cutler-Hammer, Inc., 12th & St. Paul Ave.; *for mail*, 819 N. 15th St.
CLOVIS, E. J. (J'36), Student Engr., Harnischfeger Corp., 4400 W. National Ave.; *for mail*, 2030 N. 71st St.
COAKLEY, W. E. ('24; '35), Supt., Pressed Steel Tank Co.
DAHLSTRAND, Hans ('10), Engr., Charge Steam Turbine Dept., Allis-Chalmers Mfg. Co.
DOBROGOWSKI, Rudolph A. (J'32), Draftsman, Bucyrus-Erie Co., S. Milwaukee; *for mail*, 1957 S. 29th St., Milwaukee.
DORNBROOK, Fred L. ('22), Ch. Engr., Power Plants, Milwaukee Elec. Ry. & Light Co., 132 W. Michigan; *for mail*, 4426 N. Farwell Ave.
DORNER, Fred H. ('07; '11; F'36), Manager, '27-'30; Vice-President, '31-'33; M. E., 1107 E. Knapp St.
DORSCHEL, Leonard J. (J'29), Sales Engr., Gen. Elec. Xray Corp., 940 W. St. Paul Ave., Milwaukee; *for mail*, 620 S. Ingersoll, Madison.
DOW, Herbert W. ('17), Sales Engr., Nordberg Mfg. Co.; *for mail*, 2524 E. Shorewood Blvd.
DREWRY, M. K. ('24; '32), *Junior Award*, 1931; Asst. Ch. Engr., Power Plants, Milwaukee Elec. Ry. & Light Co., Pub. Serv. Bldg.; *for mail*, 3019 S. Shore Dr.
FALK, Harold S. ('16), V. P. & Wks. Mgr., Falk Corp., 3001 W. Canal St.
FECHHEIMER, Carl J. ('27), Cons. Engr., Louis Allis Co., Stewart Ave.; *for mail*, 1930 N. Prospect Ave.
FERRIS, Walter ('07), V. P., Charge Engrg., Oilgear Co., 1403 W. Bruce St.
FICNERSKI, Paul P. (J'35), Student Engr., Harnischfeger Corp., 4400 W. National Ave.; *for mail*, 3117 W. Highland Blvd.
FITZE, Maurice E. (J'26), Test Engr., Power Plants, Milwaukee Elec. Ry. & Light Co., Pub. Serv. Bldg., Milwaukee; *for mail*, Hales Corners.
FLORY, A. C. ('19), Mgr., Steam Turbine Dept., Allis-Chalmers Mfg. Co.
FRANK, Edwin ('09; '25), Apt. 2, 1943 N. Summit Ave.
FURRER, Rudolph ('22; '28), 4059 N. Richmond Court.
GATES, Edwin L. (J'25), Secy., Engrs. Standardization Com., Allis-Chalmers Mfg. Co.
GATES, Saml. J. ('16; '25), Cons. Engr., 744 N. 4th St.
GAWRONSKI, Herbert S. (J'36), 2727 W. McKinley St.
GEERLINGS, Henry John ('13), Cons. Engr., 647 W. Virginia St.
GREENWALL, Walter L. ('11), M. E., Nordberg Mfg. Co., Chase & Oklahoma Sts.; *for mail*, 3036 S. Superior St.
GRIESHABER, Emil ('23; '35), M. E., Nordberg Mfg. Co.; *for mail*, 2928 S. Lenox St.
GUDMUNDSEN, Austin ('24; '34), V. P., Ch. Engr., Gudmundsen-Stratton Labs., Inc., 342 N. Water St.; *for mail*, 1239 N. 45th St.
HANSEN, Hans I. (J'30), M. E., A. O. Smith Corp.; *for mail*, 3508 N. 38th St.
HAWKS, Arthur S. ('04; '09), Engr., Nordberg Mfg. Co., 3073 S. Chase Ave.; *for mail*, 1716 N. Prospect Ave.
HEISE, Lorenz W. (J'27), Research M. E., Charge Sample Frame Specifications, A. O. Smith Corp., 3533 N. 27th St.; *for mail*, 2820 W. Vienna Ave.
HOLCOMB, A. Elton ('30), Sales Engr., Charge Sales, Excavating, Material Handling & Hauling Div., Koehring Co., 31st & Concordia Sts., Milwaukee; *for mail*, 1753 N. 74th St., Wauwatosa.
HOLMBERG, Einar O. ('27; '35), Ch. Engr., Calif. Div., A. O. Smith Corp., Milwaukee; *for mail*, 7428 Oakhill Ave., Wauwatosa.
HOLMBERG, Jos. Chas. ('32; '35), Squad Leader, Engrg. Dept., Chain Belt Co., 1600 W. Bruce St.; *for mail*, 1606 S. 55th St.
JACOBI, N. Edw. ('19; '35), Ch. Engr., Briggs & Stratton Corp., 1047—13th St.; *for mail*, 2429 N. Booth St.
JASPER, Thos. McLean ('26), Dir. Research, A. O. Smith Corp.
JETT, Geo. C. ('25), Partner, Engr., Charge Design, Jett & Stiemke; *for mail*, 2629 N. Summit Ave.
JETT, Robert M. (J'35), 2629 N. Summit Ave.
KING, John Belding (J'36), 1246 W. Atkinson Ave.
KLAPPENBACH, Hugo E. (J'34), c/o Lawrence E. Peterson, 312 E. Wisconsin Ave.; *for mail*, 4512 N. 27th St.
KOLLBERG, Gustaf L., ('10), Mgr., Blower & Compressor Dept., Allis-Chalmers Mfg. Co.; *for mail*, 956 N. 31st St.
KRAMLICH, C. W. ('29), Sales Engr., Fafnir Bearing Co., 610 W. Michigan St.
KREMER, Waldemar R. ('12), Gen. Sales Mgr., Vilter Mfg. Co., 2217 S. 1st St.; *for mail*, 1219 N. Van Buren St.
KRUEGER, Jos. W. (J'35), Student Engr., Internatl. Harvester Co.; *for mail*, 3022 N. Cramer St.
LAABS, Eric H. ('17; '22; '29), Supvg. Engr., Cutler-Hammer, Inc., 12th St. & St. Paul Ave.
LEWIS, Francis H. (J'32), M. E., Research Staff, A. O. Smith Corp; *for mail*, 3050 N. 41st St.
LINDEMANN, W. C. ('13; '21), Manager, '35-'38; M. E., Factory Mgr., Secy., A. J. Lindemann & Hoverson Co., 601 W. Cleveland Ave.; *for mail*, 3937 N. Lake Dr.
LINDSTROM, Arthur W. ('20; '35), M. E., Charge Maint. & Power Plant Opera., Premier Pabst Corp., 917 Juneau Ave.; *for mail*, 4729 N. Larkin St.
LIPPMANN, Arthur W. (J'33), Ch. Engr., Lippmann Engrg. Wks., 4603 W. Mitchell St.; *for mail*, 2806 S. Herman St.
LIPPMANN, Edmund E. (J'34), Engr., Lippmann Engrg. Wks., 4603 W. Mitchell St.; *for mail*, 2806 S. Herman St.
LOZAR, John A. (J'28), Planning Dept., Chain Belt Co., 1600 W. Bruce St.; *for mail*, 745 S. 31st St.
LUEDICKE, Alex. H. ('20; '35), Supvg. Engr., Gridley Dairy Co., 620 N. 8th St.
MAAGE, Alfred E., Jr. (J'31), Indus. Engr., Globe Union Mfg. Co., 900 E. Keefe Ave.; *for mail*, 3950 N. 26th St.
MacBRIAR, Wallace N. ('16), Asst. V. P., Carnation Co., 700 Gas Light Bldg.
MACKIE, Daniel M. ('14), Planning Engr., Chain Belt Co., 1600 W. Bruce St., Milwaukee; *for mail*, 6009 W. Wells St., Wauwatosa.
MacLEOD, Daniel T. ('01; '07), Spec Agt., Travelers Ins. Co., 735 N. Water St.; *for mail*, 2826 E. Linwood Ave.
MacPHERSON, David A. (J'36), Student Engr., Serv. Wks., Nordberg Mfg. Co.; *for mail*, 2997 S. Superior St.
MALISCHKE, Carl (J'33), Pres. & Treas., Chas. Malischke Co., 2518 N. 30th St., Milwaukee; *for mail*, 6466 Upper Pkwy., N., Wauwatosa.
MANIERRE, George ('17), Prop., Manierre Engrg. & Mchy. Co., 622-23 Colby Abbot Bldg.
MARTIN, Chas. R. ('21), Engr., Hyd. Dept., Allis-Chalmers Mfg. Co., Milwaukee; *for mail*, 7122 Hillcrest Dr., Wauwatosa.
MEEG, Alfred B. ('26; '33; '35), Branch Mgr., Iron Fireman of Milwaukee, Inc., 4507 W. Wisconsin Ave.
MELLOWES, Chas. N. (J'36), Mgr., Charter Wire Products Co., 627 E. Polk St.
MEYER, Hans J. ('16), Ch. Project Inspr., Wks. Progress Admin., Veterans Admin.; *for mail*, 2406 E. Shorewood Blvd.
MILLER, Robt. H. (J'35), Draftsman, Kearney & Trecker Corp.
MILLER, Roman A. (J'35), 2938 N. Booth St.
MINIBERGER, Geo. V. (J'29), Designing Engr., Devel., Harnischfeger Corp., 4400 W. National Ave.; *for mail*, 902 S. 24th St.
NEEDHAM, H. H. ('21; '35), Asst. Sales Mgr., A. O. Smith Corp., Milwaukee; *for mail*, 616 N. 67th St., Wauwatosa.
NEWHOUSE, Ray C. ('20), Ch. Engr., Crushing & Cement Mchy. Div., Allis-Chalmers Mfg. Co., 1126 S. 70th St., Milwaukee; *for mail*, 1734 N. 69th St., Wauwatosa.
NICOL, H. Erskine ('28), Research Engr., Kerner Incinerator Co., 3707 N. Richard St.; *for mail*, 2417 E. Newton Ave.
NORDBERG, Bruno V. E. ('21), Exec. Engr., Nordberg Mfg. Co.; *for mail*, 625 N. 50th St.
NYGREN, K. A. ('29), Gen. Supt., Globe Steel Tubes Co., 3839 W. Burnham St.; *for mail*, 1610 N. Hawley Rd.
NYSTROM, K. F. ('21; '25), Supt., Car Dept., Chicago, Milwaukee, St. Paul & Pacific Ry.
OBERLINK, Boyd S. (J'34), Equip. Engr., Tractor Div., Allis-Chalmers Mfg. Co.
PARSONS, Fred'k A. ('14; '21), 1506 Mariner Tower.
PATITZ, J. F. Max ('91; '00), Ch. Cons. Engr., Allis-Chalmers Mfg. Co.; *for mail*, 1447 N. 38th St.
PETER, A. G. ('16; '20; '35), Pres. & Mgr., Albert G. Peter Co., 1643 N. 24th St.; *for mail*, 3816 W. Roberts St.
PETRI, Wilbur J. (J'33), Tool Maker, Harley-Davidson Motor Co.; *for mail*, 2401 N. 45th St.
RAUNICK, Ernest J. M. ('18), Supt. Cunningham Ortmayer Co., 123 W. Michigan St.
REINHOLD, W. R. (J'32), Refrig. Sales Engr., Cutler-Hammer, Inc., 315 N. 12th St.; *for mail*, 2334 N. 59th St.
RICK, Constantine ('29; '36), Asst. to M. E., Allis-Chalmers Mfg. Co., S. 70th & W. Greenfield Ave., W. Allis; *home address*, S. 32nd & W. Layton Ave., Greenfield, Milwaukee Co.
RITTER, Willard F. (J'35), c/o Tractor Div., Allis-Chalmers Mfg. Co.
ROBERTSON, Chas. E. ('23; '35), Test Engr., Allis-Chalmers Mfg. Co.; *for mail*, 1114 S. 74th St.
ROSENBERG, Edwin C. ('25; '35), Ch. Engr., F. Rosenberg Elev. Co., 3745 N. Richards St.; *for mail*, 3356 N. Humboldt Ave.
ROSMAIT, John A. ('27), 2250 W. Roosevelt Dr.
ROSS, Hugh L. (J'29), Asst. Engr., Allis-Chalmers Mfg. Co.; *for mail*, 1344 N. Prospect Ave.

RUEGG, Clement ('19), Ch. Diesel Designer, Nordberg Mfg. Co.
RUEMELIN, Richard ('20), Pres., Ruemelin Mfg. Co., 1570 S. 1st St.; *for mail*, 4939 Cumberland Blvd., Whitefish Bay.
RUESS, Max Emil (J'36), M. E. in Eng. Design, Vilter Mfg. Co., 2217 S. 1st St.; *for mail*, 2962 S. Logan Ave.
RUSCH, Kenneth (J'33), Draftsman, Badger Meter Mfg. Co., 2357 N. 30th St.; *for mail*, 1974 S. Layton Blvd.
RUTHERFORD, Frederic C. (J'35), 615 N. 14th St.
SCHOEN, John E. ('25; '35), Prof., Mech. & Metal Engrg., Marquette Univ., 1210 W. Michigan St.; *for mail*, 2941 N. 38th St.
SCHUBERT, Gilbert W. (J'33), Serv. Dept., Allis-Chalmers Mfg. Co., Milwaukee; *for mail*, 411 Main St., Watertown.
SCHUM, Eugene C. (J'36), Engr., Nordberg Mfg. Co., 3073 S. Chase Ave.; *for mail*, 2719 E. Beverly Rd.
SEDGWICK, H. A. ('15), Gen. Supt., Cutler-Hammer, Inc., 12th & St. Paul; *for mail*, 2018 E. Lake Bluff Blvd.
SEUTTER, Louis ('18; '22; '27), Cons. Engr., 5604 W. Washington Blvd.
SIMON, Arthur ('12), E. E. Pat. Expert, Cutler-Hammer, Inc., N. 12th & W. St. Paul Ave.
SIMON, Walter A. (J'33), Engr. Opera. & Maint., Barrett Co., 4868 N. 30th St.; *for mail*, 5234 N. 37th St.
SMITH, Chas. Richard (A'18), Supt. Mech. Div., Am. Appraisal Co., 525 E. Michigan St.; *for mail*, 2147 N. 52nd St.
SMITH, Roger K. (J'35), 2330 W. Clybourn Ave.
SOULEN, Peter J. ('27; '35), Owner, Power Plant Equip., 617 N. 2nd St.
STANEK, J. H. (J'36), 4339 N. 25th St.
STARK, LaRue H. ('25), M. E., Charge Maint., Phœnix Hosiery Co., 320 E. Buffalo St.
STERNBERG, Ernest R. (J'35), Sales Engr., Sterling Motor Truck Co., Inc.; *for mail*, 246 N. 50 St.
STOESSEL, Robt. F. (J'34), Engr., Design, Oilgear Co., 1403 W. Bruce St.; *for mail*, 2907 N. 2nd St.
STROTHMAN, E. P. (J'24), 2502 E. Wood Pl.
STUCKERT, Felix J. (J'20), Ch. Draftsman, Briggs & Stratton Corp., 2711 N. 13th St.; *for mail*, 2572 N. 46th St.
TAUTZ, Herbert E. ('22; '27; '35), Pres., Delta Mfg. Co., 600 E. Vienna St.
THOMPSON, John J. (J'30), 910 E. Wisconsin Ave.
THUERMANN, Wilfred J. ('21; '25; '35), M. E., Charge Maint., Chain Belt Co., 1600 W. Bruce St.; *for mail*, 3037 N. 14th St.
TUCKER, Wm. B. ('23; '30; '35), Sales Engr., Allis-Chalmers Mfg. Co.; *for mail*, 1355 N. Prospect Ave.
TURNWALD, Wolfgang ('23), Nordberg Mfg. Co., S. Chase St.; *for mail*, 1341 S. Layton Blvd.
UIHLEIN, Wm. B. (J'07), Gen. Supt., Jos. Schlitz Brewing Co.
VALLIER, A. E. (J'35), 1140 S. 77th St.
VOGT, Robt. F. ('11), Cons. Engr., Allis-Chalmers Mfg. Co.; *for mail*, 2928 N. Farwell Ave.
WALCHER, E. A. (J'36), Apprentice, Chain Belt Co., 1600 W. Bruce St.; *for mail*, 1220 S. Layton Blvd.
WALKER, Emery L. ('10), V. P., Retired; Kieckhefer Container Co., Eddy Paper Corp., 1715 Canal St., Milwaukee; *for mail*, 7406 Hillcrest Dr., Wauwatosa.
WALKER, Fred'k W. ('98; '09), V. P., Charge Bond Investments, Northwest. Mutual Life Ins. Co., 720 E. Wisconsin Ave.
WATSON, Wm. ('20), Gen. Wks. Mgr., Allis-Chalmers Mfg. Co., Milwaukee; *for mail*, 1464 S. 76th St., W. Allis.
WHITE, Paul A. (J'31), M. E., Sales, Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio; *for mail*, 4474 N. Oakland, Milwaukee, Wis.
WHITE, Wm. Monroe ('06), Mgr., Allis-Chalmers Mfg. Co.
WILSON, Jas. ('13), Engr., Steam Turbine Dept., Allis-Chalmers Mfg. Co., Milwaukee; *for mail*, 1512 S. 77th St., W. Allis.
WILSON, John C. ('17), V. P., Cutler-Hammer, Inc.; *for mail*, 3060 N. Marietta Ave.
WILSON, Rushen A. (J'35), 853 N. 10th St.
WINTZER, H. C. (J'35), 4415 N. Stuwell Ave.
WINTZER, Rudolph ('08), Ch. Engr., Nordberg Mfg. Co., E. Oklahoma & Chase Ave.
WOLFSOHN, Robt. S. (J'33), Student Engr., Allis-Chalmers Mfg. Co.; *for mail*, 3306 W. Highland Ave.
WOOD, Chas. R. (J'35), Engr., Mfg. Dept., Allis-Chalmers Mfg. Co.
YOST, Lloyd ('26), Research Engr., A. O. Smith Corp.
YOUNG, Andrew J. ('28; '35; '35), Mchy. Engr., Fidelity & Casualty Co. of N. Y., 1040 Wells Bldg.

NEENAH

MACKINTOSH, D. ('29; '35), 621 Isabella St.
NORLING, Bert S. ('36), Design Engr., Power Equip., Kimberly-Clark Corp.

NORTH PRAIRIE, Milwaukee Section

LEUTWILER, L. G. (J'29), Pet Milk Co.

OCONOMOWOC, Milwaukee Section

HENSZEY, Roy O. ('17; '35), Ch. Engr., Carnation Co.

RACINE, Milwaukee Section

ARNOLD, Arthur B. (J'27), M. E., Modine Mfg. Co.; *for mail*, Route 4, Box 402.
BAGGOTT, S. P. (J'31), 3717 Washington Ave.
HUBER, John S. ('27; '35), Exper. Engr., Nash Motors Co., Racine; *for mail*, 800½ Milwaukee Ave., S. Milwaukee.
KARLSON, Karl W. ('29), Cons. Engr., 708 Arthur Ave.
KEITH, Robt. R. ('04; '11; '14), Mgr., Tractor Wks., J. I. Case Co.; *for mail*, R. R. 1.
MACGREGOR, Wallace F. ('01; '14), M. E., J. I. Case Threshing Mch. Co., Inc.
SIMANEK, Chas. J. (J'36), 1841 N. Main St.
SPIETH, Benj. ('21; '35), Engr., Modine Mfg. Co.; *for mail*, 2046 Deane Blvd.

RHINELANDER

SUHS, Guy H. ('25), Plant Engr., Rhinelander Paper Co.; *for mail*, 228 S. Oneida Ave.

ROTHSCHILD

KEETH, Grover ('25), Ch. Engr., Marathon Paper Mills Co.

SHEBOYGAN, Milwaukee Section

GARRETT, Roy M. (J'35), Combustion Engr., C. Reiss Coal Co.
STOLZENBURG, Frederic O. (J'32), 1125 N. 8th St.

SHEBOYGAN FALLS, Milwaukee Section

JOA, Curt G. ('35; '35), Pres., Gen. Mgr., Curt G. Joa, Inc. & Jenkins Mchy. Co., 17th, Franklin & Manitowoc Sts.

SOUTH MILWAUKEE, Milwaukee Section

BAUER, Harry E. ('29), Asst. M. E., Bucyrus-Erie Co., S. Milwaukee; *for mail*, 2746 S. Lenox St., Milwaukee.
COLEMAN, Wm. W. ('08), Pres., Bucyrus-Erie Co., S. Milwaukee; *for mail*, 1101 N. Marshall St., Milwaukee.
FYKSE, M. L. ('20), Ch. Engr., Div. B., Bucyrus-Erie Co.; *for mail*, 715 Hawthorne Ave.
KRAFT, Oscar H. (J'35), Bucyrus-Erie Co., S. Milwaukee; *for mail*, 3528 W. Highland Blvd., Milwaukee.
LEHMAN, Werner ('16), Ch. Engr., Bucyrus-Erie Co.; *for mail*, 728 Michigan Ave.
RUHLOFF, F. Carl ('25), Sales Engr., Bucyrus-Erie Co., *for mail*, 1193 Fairview Ave.
WELCH, Halbert A. ('31; '35), Mech. Draftsman, Bucyrus-Erie Co.; *for mail*, 800½ Hawthorne Ave.

SUPERIOR

ENGELKING, Walter W. ('20; '21; '35), 802 E. 7th St.
WINKELS, Walter G. (J'27), 1512 Tower Ave.
ZIMMERMAN, Frank R. ('18; '19), V. P. & Gen. Engr., Superior Iron Wks. Co., 3rd & Grand.

TOMAHAWK

BUGGE, Sven B. ('16), V. P., Gen. Mgr., Tomahawk Kraft Paper Co.

TWO RIVERS

KAHLENBERG, Roger W. (J'25), Engr., Kahlenberg Bros. Co.; *for mail*, 2611 West St.

WAUKESHA, Milwaukee Section

CHRISTIE, Ward E. (J'36), Refrig. Engr.-Student, Waukesha Motor Co.; *for mail*, 312 Maple Ave.
EASON, Clarence M. ('20), Secy., Treas., Fawick Mfg. Co.; *for mail*, 608 N. Hartwell Ave.

WAUWATOSA, Milwaukee Section

BRUHNKE, Leslie T. (J'26), L. J. Mueller Furnace Co.; *for mail*, 837 N. 63rd St.
FISCHER, Jos. C. ('24; '27), Supvg. Engr., Milwaukee County Institutions.
FODOR, Nicholas ('24; '30), Engr., Charge Oil Engines, Allis-Chalmers Mfg. Co., Milwaukee; *for mail*, 8213 Rockway Pl., Wauwatosa.
REVERE, Francis J. ('17), Asst. Engr., Steam Turbine Div., Allis-Chalmers Mfg. Co., W. Allis; *for mail*, 6719 Cedar St., Wauwatosa.
SCHAUER, H. A. ('21; '35), Pres., Hasco Valve & Mch. Co., 1819 W. St. Paul Ave., Milwaukee; *for mail*, 612 N. 68th St., Wauwatosa.
SETER, Peter K. ('34; '35), Ch. Engr., Francey Stone Co., 6506 W. State St.
WEGNER, Arnold A. ('17; '35), Ch. Engr., Conveyor Div., Chain Belt Co., 1600 W. Bruce St., Milwaukee; *for mail*, 6931 W. Wells St., Wauwatosa.
WELLAUER, Edw. J. (J'35), Research & Devel. Engr., Falk Corp., Milwaukee; *for mail*, 6325 W. North Ave., Wauwatosa.

WEST ALLIS, Milwaukee Section

ALLEN, Ernest C. ('20; '24), Engr., Steam Turbine Design, Allis-Chalmers Mfg. Co.
ARMITAGE, Jos. B. ('19), Ch. M. E., Kearney & Trecker Corp., 6784 W. National Ave.
DIMBERG, Paul C. ('23), Asst. Engr., Steam Turbine Blading, Allis-Chalmers Mfg. Co., W. Allis; *for mail*, 6525 Wells St., Wauwatosa.
ESERKALN, Theodore F. (J'33), Asst. Ch. Engr., Research, Kearney & Trecker Corp., 6784 W. National Ave., W. Allis; *for mail*, 2250 N. 62nd St., Wauwatosa.
GORMAN, Wilbur R. (J'32), Sales Engr., Allis-Chalmers Mfg. Co.; *for mail*, 1527 S. 60th St.
HOMSHER, R. Lee (J'36), Student Engr., Metal. Research Dept., Allis-Chalmers Mfg. Co., Milwaukee; *for mail*, 1520 S. 74th St., W. Allis.
LINCOLN, Chas. S. ('21), Engr., Charge Design, Crushing & Cement Mchy. Div., Allis-Chalmers Mfg. Co., 1126 S. 70th St., W. Allis; *for mail*, 6714 Cedar St., Wauwatosa.
MUELLER, Felix J. ('24), Ch. Draftsman, Steam Turbine Dept., Allis-Chalmers Mfg. Co.; *for mail*, 1558 S. 58th St.
SARVIS, Arthur L. (J'36), Student Training Course, Allis-Chalmers Mfg. Co.; *for mail*, 1432 S. 76th St.
SOTERIOU, Jas. G. ('31), 900 S. 75th St.
TRIBE, Jas. ('89), M. E., Allis-Chalmers Mfg. Co., W. Allis; *for mail*, 2523 E. Shorewood Blvd., Milwaukee.
UEHLING, Edw. A. ('83), Life Member; 2225 S. 80th St.
WEHR, C. Fred'k ('18; '35), Supt., Wehr Steel Co.
WILSON, Chas. D. (J'29), Draftsman, Allis-Chalmers Mfg. Co.

WISCONSIN RAPIDS

GOLLADAY, H. D. ('34), Engr., Charge Steam & Power, Consltd. Water Power & Paper Co.; *for mail*, 620 Wisconsin St.

WYOMING

CASPER

PARKER, Selsor S. ('27; '35), Engr., Sinclair Wyoming Oil Co.; *for mail*, 230 S. Fenway St.
ROEDEL, John K. ('28), Ch. Draftsman, Charge Design, Stand. Oil Co. of Ind.
WYCKOFF, Gerritt I. (J'34), Sales Engr., Oil Well Supply Co., 329 S. Wolcott.

LANCE CREEK

PARR, John B. ('29; '33; '35), Supt., J. M. Huber Co. of La., Inc.

LARAMIE

ARNOLD, Harry M. (J'36), 364 N. 5th St.
RAUME, Alven A. (J'35), Teacher, Sci. & Math., Laramie High Sch., 8th St.; *for mail*, 269 N. 8th St.
SIEBERT, V. W. (J'35), Sales & Serv. Engr., Oil Well Supply Co.; *for mail*, 407 S. 5th St.

PARCO

JOHNSTON, Lemuel Monroe ('26), Supt., Parco Refinery, Sinclair Refining Co.; *for mail*, P. O. Box 7.

ALASKA

See Page 37

CANADA

ALBERTA

CALGARY

HIGGINS, Alex. ('36), Head Dept. M. E., Provincial Inst. of Tech. & Art; *for mail,* 1106 Frontenac Ave.
McNAIR, A. M. ('28; '35), Ch. Engr., Steam Plant Imperial Oil Refineries; *for mail,* 1813—17th St., W.
MOORHOUSE, Milton (J'34), Budget Control Engrg., Imperial Oil, Ltd., E. Calgary St.; *for mail,* 826—14th Ave., W.
O'NEIL, Geo. W. ('28; '34), Pricer, Riverside Iron Wks., Ltd.; *for mail,* 1409—6A St., N. W.

EDMUNDSTON

ROBB, Chas. A. ('14; '35), Prof. M. E., Univ. of Alberta.

LETHBRIDGE

CONSTANTINESCU, V. ('24; '35), M. E., Owner. Union Mchy. Repair Shop, 1238—3rd Ave., S.

PICTURE BUTTE

BALLOU, Fred'k H., Jr. (J'36), Asst. M. M., Can. Sugar Factories, Ltd., Raymond; *for mail,* Picture Butte.

BRITISH COLUMBIA

VANCOUVER

BALLOU, Fred'k H. ('15; '19), Ch. Engr., Can. Sugar Factories, Ltd., Picture Butte & Raymond, Alta. & B. O. Sugar Refining Co., Ltd., Vancouver (latter address for mail).
HOSFORD, Wm. F. (J'34), Foreman, Pullman Co., C. P. R. Sta.
PAULSON, P. E. (J'35), Asst. Supt., Canadian Fishing Co., Ltd., Gore Ave.
SAWFORD, Frank ('09), M. E. & E. E., 510 Credit Foncier Bldg.
SCOTT, W. O. C. ('36), Asst. Supt., Shop, Dominion Bridge Co., Ltd., 275 W. 1st Ave., Vancouver; *for mail,* 212 E. 11th St., N. Vancouver.
SIMPSON, Geo. B. ('22), Mgr., B. C. Conveying Mch Co., 123 Pender St., W.
SLATER, Fred'k ('28; '35), Maint., Natl. Harbor Bd., Dunlevy Ave.; *for mail,* 3483 W. 20th Ave.
TAYLOR, A. J. T. ('14; '19), Pres., First Narrows Bridge Co., Ltd., 1921 Marine Bldg.
TAYLOR, Dewitt M. ('14; '20), Assoc. Prof. M. E. Univ. of British Columbia, Vancouver, B. C. Can.; *for mail,* 99 S. Central Ave., Wollaston Mass.
WALKEM, Geo. A. ('29), Managing Dir., Vancouver Mchy. Depot, Ltd., 1155—6th Ave., W.

MANITOBA

WINNIPEG

BUTLER, Ernest W. R. (J'26), Mgr., West. Can., Bailey Meter Co., Ltd., 906 McArthur Bldg.
HALL, Norman M. ('21), Cons. M. E., Prof. M. E., Univ. of Manitoba.
KIPP, Theo. ('24), V. P. & Managing Dir., Kipp Kelly, Ltd., 68 Higgins Ave.; *for mail,* 1030 Wellington Crescent.
STEWART, R. A. ('27; '35), Ch. Inspr., Bur. of Labor, Manitoba Provincial Govt., 332 Legislative Bldg.

NEW BRUNSWICK

EDMUNDSTON

WHITE, Frank O. ('20), Ch. Engr., Fraser Cos., Ltd.

ST. JOHN

CLARK, C. Gordon (J'30), Asst. Ch. Engr., Charge Design & Devel., Atlantic Sugar Refineries Ltd.; *for mail,* 201 Duke St.
RING, Major Roy A. ('29), Ch. Engr., Atlantic Sugar Refineries, Ltd., Charlotte St.

NOVA SCOTIA

AMHERST

ROBB, D. W. ('88), 98 Church St.

YARMOUTH-NORTH

WATERMAN, Henry A. ('30), Cons. Engr., Box 144.

ONTARIO

AMHERSTBERG, Detroit Section

KEYES, Stuart N. (J'34).

BRANTFORD, Ontario Section

CARISS, Carington C. ('11; '18), Ch. Engr., Design, Waterous Eng. Wks. Co., Ltd., Market St.; *for mail,* 95 William St.
WATEROUS, Chas. A. ('16), V. P. & Gen. Mgr. Waterous Eng. Wks. Co., Ltd.

CHATHAM, Detroit Section

MOORE, John C. S. (J'30), Plant Engr., British Leaf Tobacco Co. of Can., Ltd., Box 10.

COPPER CLIFF

SCHWARTE, John ('29), Designing Engr., Ontario Refining Co., Ltd., Copper Cliff; *for mail,* 36 Beech St., Sudbury.

DUNDAS, Ontario Section

BERTRAM, H. Graham ('16; '21), V. P., Gen. Mgr., John Bertram & Sons Co., Ltd.

EAST WINDSOR

PREUTHUN, Paul J. ('23; '35), Albert Kahn, Inc. 1440 Victoria Ave.; *for mail,* 15 Shepherd St

FALCONBRIDGE

BUCHMANN, Karl E. ('25; '31; '35), Designing Draftsman, Falconbridge Nickel Mines, Ltd.

GALT, Ontario Section

ELLIOTT, Robt. B. ('22; '35), Proposition Engr. Babcock-Wilcox & Goldie-McCulloch, Ltd.; *for mail,* 93 Wellington St.
GOLDIE, Alex R. ('02; '21), Vice-Chmn. Bd., Babcock-Wilcox & Goldie-McCulloch, Ltd.
OSBOURNE, Wm. Andrew ('30; '35), V. P., Charge Sales, Babcock-Wilcox & Goldie-McCulloch, Ltd.
SHELDON, Wm. D. (J'28), Ch. Engr., Sheldon, Ltd.
SPOTTON, Arthur K. ('06; '21), Advisory Engr.. Babcock-Wilcox & Goldie-McCulloch, Ltd. Grand Ave., S.; *for mail,* 92 Wentworth Ave.

GORDON BAY

WARDWELL, Frank W. ('17).

HAMILTON, Ontario Section

ANDERSON, Otto H. ('23), Ch. M. E., Natl. Steel Car Corp., Ltd.
GALLOWAY, Jas. W. ('19; '26; '35), Plant Engr. B. Greening Wire Co.
LIDDINGTON, Stanley J. ('27; '35), M. E., Canadian Westinghouse Co., Ltd.; *for mail,* 27 Kensington Ave., N.
POOK, Chas. H. O. ('15), Wks. Mgr., Canadian Westinghouse Co., Ltd.
VILA, J. W. (J'36), Rate Dept., Canadian Westinghouse Co., Ltd., Sanford St., N.

INGERSOLL, Ontario Section

DEACON, Allin P. (J'36), Subinspr., Morrow Screw & Nut Co., Ltd.; *for mail,* 163 Wonham St.

KINGSTON

CAVIN, Gustave ('16), Ch. M. E., Can. Loco. Co.. Ltd.

KITCHENER

BEAVERS, Geo. R. ('30; '35), Ch. Engr., Canadian Blower & Forge Co., Ltd.; *for mail,* Apt. D, 60 Church St.

LONDON, Ontario Section

GILBERT, Russell L. (J'24), Draftsman. Spartan Radio, Inc., Elm St.; *for mail,* 522 Piccadilly St.
LEONARD, Col. Ibbotson ('06; '21), Pres., E. Leonard & Sons, Ltd., 381 York St.
MORGAN, A. Hedley ('19), V. P., Wks. Mgr., E. Leonard & Sons, Ltd.; *for mail,* 294 Hyman St.
SPENCER, Lieut.-Col. Alex. Chas. ('21), Cons. Engr., R. R. 3.

NEW TORONTO, Ontario Section

CORNISH, D. F. (J'34), Engr., Anaconda Am. Brass Co., New Toronto; *for mail,* 95 Dinnick Crescent, Toronto.

NIAGARA FALLS, Buffalo Section

ANDREWS, Saml. W. ('26), M. E., H. G. Acres & Co., Ltd.
DEPAIRON, Jean ('29; '35), Engr., Charge Design. Pollard Mfg. Co., Ltd., Ferguson Ave.; *for mail,* 394 Ellis St.

OJIBWAY, Detroit Section

BALTZELL, Will H. ('10), Ch. Engr., Canadian Steel Corp., Ltd., Ojibway, Essex Co.

OTTAWA

CRAIN, Harold F. (J'33), V. P., Charge Prod., Crain Printers, Ltd., 145 Spruce St.
PARKIN, John Hamilton ('19; '24), Officer in Charge, Div. of M. E., Natl. Research Council, 7 Sussex St.
ROWAN, John J. (J'36), 162 Friel St.
SAMPSON, Frank A. (J'27), Pilot Officer, Royal Canadian Air Force, Air Hdqrs.

PETERBORO, Ontario Section

CUNNINGHAM, Geo. A. (J'30), 331 Reid St.
McBRIEN, Robt. E. ('25; '32; '35), Designing Draftsman, Canadian Gen. Elec. Co., Park St.; *for mail,* 274½ McDonnel St.
SANGSTER, Wm. ('94), Engr., Charge Design. De Laval Co., Ltd., 113 Park St.

PETROLIA

RANNEY, Leo ('26).

PORT ARTHUR, Ontario Section

ROGERS, John A. (J'25), Provincial Paper, Ltd.

ST. CATHERINES

BLUE, A. C. ('28; '35), M. E., Design Erection. Foster Wheeler, Ltd.
COOK, Thos. J. ('24), Asst. Wks. Mgr., McKinnon Industries, Ltd., Subsidiary of Gen. Motors Corp.

SAINT MARYS, Ontario Section

MITCHELL, Frank (J'36), Box 712.

SANDWICH, Detroit Section

SHOWERS, Carl G. ('26; '35), Asst. Ch. Oper. Engr., Alkali Div., Canadian Industries; *for mail,* 106 Brook St.

SARNIA

NOBLE, Geo. (J'34), M. E., Imperial Oil, Ltd.; *for mail,* 274 Russell St., N.
STUBBS, Wm. F. ('21), Combustion Engr., Imperial Oil, Ltd.; *for mail,* 340 N. McKenzie St.
WHITE, John R. (J'31), Engr., Devel. Dept., Imperial Oil, Ltd.; *for mail,* 433 London Rd.

SAULT STE. MARIE

GALLAGHER, Thos. G., Jr. ('21), 39 Summit St.

SMOOTH ROCK FALLS, Ontario Section

FOLEY, Glenroy B. (J'28), Engrg. Dept., Abitibi Power & Paper Co., Ltd.

SOUTH PORCUPINE

ANDREW, Percy J. ('31; '35), Engr., Dome Mines Co., Ltd.

SUDBURY

FALCONER, Duncan J. (J'36), Lebel Ore Mines. Box 156.

THOROLD

CALNAN, Edw. Jos. (J'30), Steam Control Engr., Ont. Paper Co., Ltd.
McADAM, H. Bruce ('24; '30; '35), Process Control Supt., Ontario Paper Co., Ltd.

TORONTO, Ontario Section

AEBERLI, Adolf ('16), M. E., Hydro Elec. Power Comm. of Ont., 620 University Ave.; *for mail* 257 Kingswood Rd.
AGNEW, T. Charles (J'30), Engr., Charge Repair Shop & Serv., Minneapolis-Honeywell Regulator Co., Ltd., 117 Peter St.; *for mail,* 350 Concord Ave.
ALDRIDGE, Eugene F. ('26; '35), Ch. Inspr.. Engrg. Dept., Gen. Accident & Assurance Co. of Can., 357 Bay St.
ALLCUT, Edgar A. ('22), Prof. M. E., Univ. of Toronto.
ANGUS, Harry H. ('19), Cons. Engr., 34 Farnham Ave.
ANGUS, Robt. W. ('01; '08; F'36), Vice-President. '24-'26; Prof., Head Dept. M. E., Univ. of Toronto.
ASELTINE, Arthur W. ('25; '35), Pres., Gen. Mgr.. Sterling Appraisal Co., Ltd., 9 Wellington St., E.
BALL, Wm. S. ('32), Plant Engr., Lever Bros.. Ltd., 299 Eastern Ave.
BELL, F. Jno. ('31), Rep. Mfrs. Heavy Engrg. Equip., Royal Bank Bldg., Toronto 2.
BILLINGS, Donald G. (J'36), Mgr., M. E., Mchy. Maint. Serv., 33 Sherbourne St.; *for mail,* 411 Belzize Dr.
BRICKENDEN, W. T. ('23; '30; '35), M. E., Indus. Engrg., Thorne Mulholland, Howson & McPherson, 1018 Federal Bldg.; *for mail,* 301 Silverbirch Ave.
BURGESS, J. R. ('24; '35), Mech. Supt., Stauntons Ltd., 944 Yonge St.
BURGESS, Kenneth A. ('21; '35), Safety Engr. Canadian Kodak Co., Ltd., Toronto 9; *for mail* 13 Somerville Ave., Mount Dennis.
CAMPBELL, Colin G. (J'36), Demonstrator Thermodynamics, Univ. of Toronto; *for mail* 76 Binscarth Rd.
CLARKE, Sidney G. ('22; '26), Ch. Draftsman Hamilton Gear & Mch. Co., 76 Van Horne St. *for mail,* 245 Arlington Ave.
CLAYTON, Lewis J. ('27), M. E., Viceroy Mfg. Co. Ltd., 26-32 Alpine Ave.; *for mail,* 88 Clendennan Ave.
DAVIS, Cecil R. (J'24), Sales Mgr., Davis Automatic Controls Co., 145 Wellington St., W.
DICKEY, Arthur J. ('15; '35), V. P., Gen. Mgr. C. A. Dunham Co., Ltd., 1523 Davenport Rd.; *for mail,* 9 Mossom Pl.
DOWDELL, S Harold (J'34), Supvr. Piece Rates Canadian Gen. Elec. Co., Ltd., 224 Wallace Ave.
DOWLER, E. A. (J'25), Sales Engr., B. G. Sturtevant Co. of Can., Ltd., 137 Wellington St. W.; *for mail,* 9 Prince Arthur Ave.
EAST, Frank G. (J'30), Designing Engr., Gear Reduction Units, Hamilton Gear & Mch. Co. 76 Van Horne St.; *for mail,* 251 Clinton St.
ELAND, F. H. ('30; '35), Ch. Engr., Dodge Mfg Div., U. S. Steel Corp., 58 Pelham Ave. Toronto; *for mail,* 70 Superior Ave., Mimico
ELLIS, Owen Wm. ('30), Dir. Metallurgical Research, Ont. Research Foundation, 43 Queen's Park.
EWENS, Frank G. (J'36), Demonstrator in Thermodynamics, Univ. of Toronto; *for mail,* 83 Madison Ave.
FEAR, S. Lorne ('24), Asst. M. E., Hydro Elec Power Comm. of Ont., 670 University Ave.; *for mail,* 18 Vesta Dr.
FISHER, Geo. H. B. (A'26), Canadian & Gen. Finance Co., Ltd., 25 King St., W.
GALLAGHER, Edmund G. (J'34), Hyd. Demonstrator, Univ. of Toronto; *for mail,* 16 Cedar Ave.
GILLESPIE, R. G. (J'36), Maint. Engr., Garage Dept., Toronto Transportation Comm., 35 Yonge St.; *for mail,* 358 Davenport Rd.
HALLY, Gordon H. ('23; '35), Dept. of M. E. Faculty of Applied Sci., Univ. of Toronto. Toronto; *for mail,* P. O. Box 342, Aurora.
HAMILTON, Chester B., Jr. ('09; '14), Life Member; Pres. & M. E., Hamilton Gear & Mch. Co. 76 Van Horne St.
HENDERSON, W. J. (J'34), 326 Elm Rd.
HILL, H. G. (J'35), Engr., Air Conditioning Design, Gurney Fdy. Co., Ltd., Junction Rd.; *for mail,* 83 Lawrence Ave., E.
HOLMESTED, D. S. (J'36), 151 Dunvegan Rd.
HUDSON, F. W. ('11), Asst. to Pres., Natl. Iron Corp., Ltd., Cherry St.; *for mail,* 82 Wolfrey St.
JONES, Allan T. (J'30), Engr., Charge Design & Prod., S. A. Armstrong, Ltd., 720 Bathurst St.; *for mail,* 325 Kingwood Rd.
KERR, Henry K. (J'36), Sales Engr., Canadian Gen. Elec. Co., Ltd.; *for mail,* 44 Blythwood Rd.
KURTZ, J. V. (J'36), 177 Rosewell Ave., Toronto 12.
LEEPER, R. W. ('08; '21), Mgr., Pulp & Paper Sec., Canadian Gen. Elec. Co., Ltd., 212 King St., W., Toronto 2.
LORD, G. Ross (J'32), Lecturer, M. E., Univ. of Toronto.
MARTIN, Evan S. ('20), Secy., Treas., Jas. A. Wickett, Ltd., 16 Saulter St.
McINTOSH, W. G. ('30), Asst. Prof. M. E., Univ. of Toronto.
MICKLETHWAITE, Wm. E. (J'35), Univ. of Toronto; *for mail,* 886 Ossington Ave.
MILLER, C. Arthur (J'36), Engrg. Staff, Link Belt Ltd., 791 Eastern Ave.; *for mail,* 9 Kingscourt Dr.
MORRISH, Murray (J'34), Asst. to Plant Engr., Lever Bros., Ltd., 299 Eastern Ave., Toronto; *for mail,* Highland Creek.
MUNROE, Harold S. ('19), V. P. & Cons. Engr., Ventures, Ltd., 25 King St., W.
NAGLER, Forrest ('18), Life Member for Distinguished Service, '21; Ch. Engr., Canadian Allis-Chalmers, Ltd., 212 King St., W.
NEEDHAM, Robt. J. ('20), M. & E. E., Canadian Natl. Ry., Can. Natl. Exp. Bldg.; *for mail* 64 Humber Trail.
OLVER, Albert S. (J'29), Special Rep., Ethyl Gasoline Corp., 302 Bay St., Toronto 2; *for mail,* 2 Ridge Dr., Toronto 5.
O'NEILL, Theo. (J'33), Field Engr., Gutta Percha & Rubber, Ltd.; *for mail,* 72 Indian Rd.. Crescent.
ROBINSON, Walter P. ('13; '26), Pres., McCarthy & Robinson, 2 Neville Park Blvd.
ROBSON, W. J. (J'35,) 97 Barton.
ROGERS, J. Elsworth ('24; '33; '35), V. P., Rogers Majestic Corp., 622 Fleet St.; *for mail* 99 Poplar Plains Rd.
RUDE, Robt. L. ('34), Refinery Supt., British Am. Oil Co., Ltd., 1305 Royal Bank Bldg.
SERVICE, Geo. ('23), M. E., Hydro Elec. Power Comm. of Ont., 620 University Ave.; *for mail* 72 Briar Hill Ave.
SHABSAY, Saul ('29; '35), Sales Mgr., Tower Ptg. & Publ. Co., 21 Inkerman St.; *for mail,* 448 Montrose Ave.
SHELDEN, W. L. ('36), Designing Engr., Water Supply Sec., City of Toronto, Rm. 320, City Hall; *for mail,* 190 St. George St.
SHIPLEY, K. R. (J'34), Sales Engr., Peacock Bros., Ltd., 925 Federal Bldg., Toronto; *for mail,* 852 Hellmuth Ave., London.
THOMPSON, Wm. Thos. (J'35), 4 Chesterhill Rd.
TRELOAR, Jas. B. (J'36), Engr., Charge Methods & Wage Rates, Aristocrat Mfg. Co., Ltd., 7 Fraser Ave.; *for mail,* 104 Lansdowne Ave.
TRUMAN, Fred'k (J'36), Engr., Charge Design Jas. Morrison Brass Mfg. Co., Ltd., 276 King St., W., Toronto 2; *for mail,* 79 Clovelly Ave., Toronto 10.
VAN BENSCHOTEN, Jay ('21; '35), Mgr., Wallace & Tiernan, Ltd., 32 Front St., W.; *for mail* 193 Rosedale Heights Dr.
WALLACE, Wm. Anderson (J'35), Jr. Mar. Engr. Imperial Oil Co., Ltd., 56 Church St.
WELFORD, P. G. ('14; '25; '35), Sales Engr.. Link Belt. Ltd.
WEST, John T. (J'36), Draftsman, J. & J. Taylor. Ltd., Toronto Safe Wks., 145 Front St., E.
WESTON, John F. (J'34), Factory Admin., Gutta Percha & Rubber Co., Ltd., 135 O'Hara Ave.
WHITE, Albert F. ('18), Dist. Mgr., Stephens-Adamson Mfg. Co. of Can., Ltd.; *for mail,* 130 Glendale Ave.
WIREN, Robt. C. ('26; '30; '35), Lecturer. Charge Lecturing & Lab. Wk., Univ. of Toronto.

WALLACEBURG, Ontario Section

CAMPBELL, Wm. A. (J'36), Jr. Engr., Maint. Can. & Dominion Sugar Co., Ltd., Wallace St.; *for mail,* 744 Wellington St.

WATERLOO, Ontario Section

SNIDER, A. M. ('19; '25; '35), Asst. Gen. Mgr.. Waterloo Mfg. Co., Ltd.

WELLAND, Ontario Section

BATCHELDER, Nelson A. ('20), Gen. Mgr., Empire Cotton Mills, Ltd., Grove & Hellems Sts.
BURNS, Chas. H. McL. ('22), Can. Fdys. & Forgings, Ltd.; *for mail,* 105 Dorothy St.
CLARKE, Jas. Bevan (J'36), Machinist, Welland Mch. & Tool Co.; *for mail,* 15 Randolph St.
MOORE, Walter A. ('30; '35), 17 Spencer St.
STEPHENSON, John ('28; '35), 209 W. Main St.

WINDSOR

GIFFORD, Jos. F. ('26; '35), Gen. Supt., Internatl. Playing Card Co., 1037 Merser St., Windsor; *for mail,* R. R. 1, S. Windsor.
PELLETT, W. H. (J'35), Designer, Jig & Fixtures. Bendix-Eclipse of Can., Ltd., Argyle Rd.
WALKER, Gilbert S. ('04), 454 Victoria Ave.

QUEBEC

ACTON VALE

LABREQUE, Roger J. (J'34), Asst. Supt., Plant Engr., Acton Vale Silk Mills.

ASBESTOS

TECTOR, Albert D. ('30; '35), Mfg. Supt., Can. Johns-Manville Co., Ltd.; *for mail,* Box 174.

BROWNSBURG

FREELAND, Wesley Wm. (J'35), M. E., Asst. to Supt., Metallic Processing & Tool Rm.. Dominion Ammunition Div., Canadian Industries, Ltd.

DOLBEAU

COWAN, Ben (J'32), Mfg. Dept., Lake St. John Power & Paper Co., Ltd.

KENOGAMI

GOUGH, John B. ('24), M. E., Asst. to Exec., Price Bros. & Co., Ltd.

LACHINE

MACKENZIE, Frank C. (J'36), Design, Detailing Cranes & Hoists, Dominion Bridge Co., Ltd.; *for mail,* 531 St. Joseph St.

MONTREAL

ADOLPHUS, Kenneth B. H. ('33; '35), Mech. Draftsman, Canadian Pac. Ry.; *for mail,* Box 221, Sta. B.
ATTENDU, André C. ('27), Pres. & Gen. Mgr.. Attendu-Diesel Engine, Ltd., 3847 St. Hubert.
ATWOOD, Wm. S. ('08), V. P., Charge Opera.. Canadian Car. & Fdy. Co., Ltd., 621 Craig St., W.
BEAUSOLEIL, R. J. ('32), 274 St. Catherine St., W.
CLARK, Wm. H. D. (J'29), Combustion Engrg. Corp., Ltd., Dominion Square Bldg.
CLEGG, Wm. H. ('26), Ch. Inspr., Air Brakes. Canadian Natl. Rys., 360 McGill St.
COMBE, F. A. ('20), Cons. Engr., 1188 Phillips Pl.
COOPER, Saml. J. ('26; '35), Engr., Cent. Control Office, Canadian Marconi Co., 11 St. Sacrament St.
DILLON, J. J. ('30), Ch. M. E., Bell Tel. Co.. Beaver Hall Hill.
DURLEY, Richard J. ('99), Gen. Secy., Engrg. Inst. of Can., 2050 Mansfield St.
ELLIS, Frank A. ('28; '35), 2347 Hingston Ave. Notre Dame de Grace.
FARMER, John T. ('02; '13), M. E., 1106 Beaver Hall Hill.
FRIEDMAN, Ferdinand J. ('13; '21), M. E.. McDougall & Friedman, 1221 Osborne St.. Montreal, Que., Can. & 31 Union Square, New York, N. Y. (former address for mail).
GARLAND, Jas. ('21), Gen. Supt., Dominion Engrg. Wks., Ltd., Box 3150.
GRISWOLD, H. J. (A'13), Pres., Griswold & Co., Ltd., 407 McGill St.
HALL, John G. ('28; '35), Asst. to V. P., Combustion Engrg. Corp., Ltd., 1010 St. Catherine St.
HATHAWAY, Jos. D. ('14), V. P. Charge Mfg. No. Elec. Co., Ltd., 1261 Shearer St., Montreal; *for mail,* 700 Aberdeen Ave., Westmount.
HIGGINSON, Thos. H. ('21), Managing Dir. "Automatic" Sprinkler Co. of Can., Ltd., 6998 Jeanne Mance St.
HOLT, W. G. H. (J'36), Detailer, Dominion Bridge Co., Ltd., Lachine; *for mail,* 19 Campbell Ave.. Montreal, W.
KENNEDY, Earle V. N. (J'28), Aluminium Ltd.. 1000 Dominion Square Bldg.
LARKIN, Albert C. ('95; '05), Engr., Continental Can Co. of Canada, Ltd., 2600 Mullins St.; *for mail,* 5320 Monkland Ave.
LAURIE, Albert ('21), Owner, Laurie & Lamb Power Plant Engrg. & Sales, 300 St. Sacrament St.
MACAFEE, R. E. ('24), Mgr. East. Branch, Babcock-Wilcox & Goldie-McCulloch, Ltd., 312 Canada Cement Bldg.
McCRADY, Louis DeB. ('21), Ch. Engr., Canadian Industries, Ltd., Library, P. O. Box 1260.
McGEE, J. John ('24; '35), Draftsman, Engrg. Dept., Canadian Pac. Ry., Rm. 401, Windsor Sta., Montreal; *for mail,* 5939 Dorocher Ave., Outremont.
NEWILL, Geo. E. ('20), Cons. Engr., 1178 Phillips Pl.
O'SHEA, Daniel W. ('27), 1075 Mount-Royal Blvd., Outremont.
PRADL, Geo. (J'30), Engr., Charge Design, Canadian Copper Refiners, Ltd., P. O. Box 489. Montreal; *for mail,* 11780 Notre Dame St., E. Pointe-aux-Trembles.
RANKIN, Robt. A. ('32; '35), M. & E. Engr.. Ernest Cormier, Arch. & Engr., 2039 Mansfield St.
RICHARDS, W. A. (J'28), Sales Serv. Engr., Bailey Meter Co., Ltd., 980 St. Antoine St.. Montreal. Que.; *for mail,* 48 Fairhalt Rd., S., Hamilton, Ont.
ROBERTS, Arthur R. ('17), Prof. M. E., McGill Univ., Sherbrooke St.

ROBERTS, John ('34), Ch. of Motive Power & Car Equip., Canadian Natl. Rys., 360 McGill St.
ROBINSON, E. A. ('35), Pres., Robinson Oil Burning Systems, 220 Elm Ave.
SCOTT, Wm. G. ('21; '35), Howard Smith Paper Mills, Ltd., 407 McGill St.; *for mail,* 3515 Durocher St.
SCRIVENER, R. H. (J'36), 19 Campbell Ave., Montreal W.
SETON, B. W. ('31), Propr. & Dir. Engr., Seton Engrg.-Inspc. Co., 660 St. Catherine St., W.
SMITH, Geo. Hillier ('27; '35), Engr., Matls. Handling Dept., Plessisville Fdy., Ltd., 714 St. James St.; *for mail,* 5361 Coolbrooke Ave., Notre Dame de Grace.
SNAITH, Wm. ('22), Cons. Indus. Engr., Apt. 33, 4555 Sherbrooke St., W.
STADLER, John ('20), Cons. Engr., 1117 St. Catherine St., W.
VAUGHAN, H. H. ('99; F'36), Vice-President, '11-'12 and '23; Pres., Canadian Foreign Investment Corp., 1111 Beaver Hall Hill.
VIBERG, Ernest R. ('18), Ch. Engr., Charge Design, Canadian Car & Fdy. Co., Ltd., 621 Craig St., W.
WELDON, R. Laurence ('20; '25; '27), Pres., Bathurst Power & Paper Co., Ltd., Rm. 620, 1050 Beaver Hall Hill.
WHITE, W. E. (J'35), Devel. Engr., Charge Testing Equip. Design, No. Elec. Co., Ltd., 1261 Shearer St.; *for mail,* 3577 Peel St.

NORANDA

SINCLAIR, R. McH. (J'34), Mem. M. E. Staff, Noranda Mines, Ltd.; *for mail,* Horne Hotel.

PLESSISVILLE

BOISVERT, J. B. ('31; '35), Ch. Engr., Charge Design, Plessisville Fdy., Ltd.; *for mail,* 128 Des Erables.

QUEBEC

HUESTIS, Harry E. ('21), Asst. Engr. (M. E.), Natl. Harbors Bd., Quebec Harbor.

RIVIERE du LOUP

WARREN, Kenneth L. ('07), Pres., Managing Dir., Warren Co., Ltd., Riviere du Loup (en bas).

ST. JOHNS

McCUTCHEON, Andrew ('20), Wks. Mgr., Singer Mfg. Co., 165 St. Paul St.

ST. LAURENT

LEDINGHAM, W. E. (J'36), Noorduyn Aircraft, Ltd., St. Laurent, Que.; *for mail,* 314 Oriole Pkwy., Toronto, Ont.

SHAWINIGAN FALLS

BALKO, Geo. A. ('19; '28), Consltd. Paper Corp., Ltd.
CORNELIUS, Charles Taylor (J'26), Asst. Supt., Charge Wire Mill, Aluminum Co. of Can., Ltd.
EASTON, Wallace M. (J'34), Engrg. Dept., Belgo Div., Consltd. Paper Corp., Ltd.

THREE RIVERS

BUTLER, Ernest ('22; '35), Engr., Charge Design, Wayagamack Div., Consltd. Paper Corp., Ltd.; *for mail,* 530 St. Francois Xavier St.

WESTMOUNT

CAMERON, Norman Chas. ('17), Engr., Maint., Design & Const., Imperial Tobacco Co. of Can., Ltd., 3810 St. Antoine St., Montreal; *for mail,* 466 Mountain Ave., Westmount.

SASKATCHEWAN

MOOSE JAW

ROGERS, Alfred A. ('16), Minnesota Loan & Trust Co., Minneapolis, Minn., and Natl. Light & Power Co., Moose Jaw, Sask., Can.

REGINA

COLE, Albert L. ('25), Plant Engr., Light & Power Dept., City of Regina, Cor. Broad & Dewdney; *for mail,* 22 Braemer Apts.
CRUMP, Norris R. (J'29), Loco. Foreman, Canadian Pacific Ry.; *for mail,* 2923 College Ave.

NEWFOUNDLAND

CORNER BROOK

DOWNIE, John S. ('26; '35), Designing Engr., Internatl. Paper & Power Co.

ST. JOHNS

CAMPBELL, Richard J. (J'31), Sales, Erection Engr., Clayton Constr. Co.
WRIGHT, Alan S. (J'34), 119 Gower St.

MEXICO

FRESNILLO, Zacatecas

CARSWELL, John M. ('32; '35), Power Plant Supt., Fresnillo Co., S. A.
HINRICHS, Ernst ('36), Advisory Engr., Fresnillo Co., S. A.

LOS MOCHIS, Sinaloa

AVALOS-VEZ, Bernardo ('24; '34), Engr., Charge Factory, United Sugar Cos., S. A.
CONNON, Geo. W. ('07), Mgr., United Sugar Cos., S. A.
STEEL, John (J'27), Ch. Engr., United Sugar Cos., S. A.

MAZATLAN, Sinaloa

COGSWELL, Jas. B. ('23; '35), Apt. No. 75.

MEXICO, D. F. (Mexico City)

CAMP, Geo. D. ('30), Cons. Engr., Gante 15; *for mail,* Apartado 1005.
CONWAY, Geo. R. G. ('13), Pres., Mex. Light & Power Co., Ltd., also Mex. Tramways Co., Apartado 124 Bis.
DEL PASO, Alejandro ('24; '32; '35), Engr., Charge Design, Sub-Comite de Construccion, Balbuena; *for mail,* 11a Jalapa 203-A.
FIERRO, Santos ('33; '35), Asst. Supt., Motive Power & Mchy., Natl. Rys. of Mex.; *for mail,* Buenavista.
GALE, Warren D. ('14; A'26), Gen. Mgr., Am. Book & Printing Co., S. A., 13A Bolivar 163.
GROVE, Wm. G. ('18), Professional Engr., Despacho 311, Calle de Balderas 32.
LEMAISTRE, Georges, Jr. (J'32), Advis. Engr., Tech. Dept., Productora Importadora de Papel, S. A. (PIPSA), Bucareli 12; *for mail,* Santa Maria 51, Col. del Valle.
MACIAS, Carlos ('28; '35), Gen. Mgr., Electromotor S. A., Isabel la Catolica 43; *for mail,* 3A Calle de Zarco 59.
MACORRA, Jose de la ('22; '27), Asst. Mgr., Tech. Dir., San Rafael Paper Co., P. O. Box 469.
MAHON, Wm. J. ('24; '34; '35), Rep., U. S. Rubber Co., Apartado 25 Bis.
MARROQUIN, Carlos F. ('32; '35), Ch. Engr., Secretaria de Comunicaciones y Obras Publicas; *for mail,* P. O. Box 2565.
MARTINEZ, Claudio J. ('31), Paseo de la Reforma 183.
MARTINEZ, Juan J. (J'29), Paseo de la Reforma 183.
McNEILL, K. S. ('29; '35), Supt. of Shops, Mex. Tramways Co., Dr. Lavista 164.
MORALES, P. C. ('22), Supt M. P. & Mchy., FF. CC. Nacionales de Mex., Estacion Buenavista; *for mail,* Chopo 24.
TURNER, Wm. C. ('13; '20), Ingenio San Cristobal, Capuchinas 59.
ZILBOORG, Jas. M. ('21; '28; '35), Charge Power Sales, Cia. Impulsora de Empresas Electricas, S. A., Apartado 8 Bis.

MONTERREY, Nuevo Leon

LEACH, Harry E. ('21; '35), Wks. Mgr., Portland Cement Co., P. O. Box 392.
SADA, Luis G. ('20), Indus. Engrg., P. O. Box 106; *for mail,* Hidalgo Pointe 2405.

SAN RAFAEL, Mexico

BORDA, Nicholas Blumberger ('29; '32; '35), Ch. M. E., Charge Maint. & Research, Cia de las Fabricas de Papel de San Rafael y Anexas, S. A.

TAMPICO, Tamaulipas

CLARK, Saml. W. ('33), Apartado 18.

CENTRAL AMERICA

CANAL ZONE

See Page 44

COSTA RICA

SAN JOSE

PICADO, Ramon M. ('18; '35), Cons. Engr.
PURDY, Henry T. ('09), Mgr. & Power of Atty., H. T. Purdy, Inc., P. O. Box 750.

TURRIALBA

GOODE, Curtis B. ('20), Mgr., Dominica Farm & Industrial Corp.; *for mail,* La Dominica.

REPUBLIC OF PANAMA

PANAMA

McKAY, J. B. (J'36), Calle 13 Oeste 7.
PEREZ, M. ('31; '35), P. O. Box 226.

WEST INDIES

ARUBA, D. W. I.

ARUBA

BESHERS, Hugh Monahan ('32), Asst. Gen. Supt., Aruba Refinery, Lago Oil & Transport Co., Ltd.
CLEMENTS, Bert M. ('26; '31; '35), c/o Lago Oil & Transport Co., Ltd.
FORSTER, Carl P. (J'28), Lago Oil & Transport Co., Ltd., Box 240.
KELLER, Geo. H. ('32), Ch. Engr., Lago Oil & Transport Co., Ltd.
WHEELER, H. Elmer (J'29), Ch. of Instrument Dept., Lago Oil & Transport Co., Ltd., Box 912.

BERMUDA

HAMILTON

WATLINGTON, E. Hugh ('31), Dept. Mgr., Pearman Watlington & Co.

CUBA

BANES, Oriente

GONZALEZ, Eduardo D. (J'31), Asst. M. E., Charge Maint., United Fruit Co.
MATTSON, Irwin F. ('36), Supt. Engrg., United Fruit Co.

CAMAGÜEY, Camagüey

DEVARONA-AGÜERO, Pablo ('27; '34; '35), Asst. Supt., M. P. & Shops, Consltd. Railroads of Cuba; *for mail,* Joaquin Agüero 25.

CENTRAL HERSHEY, Havana

MICHELENA, Justo L. ('27; '35; '35), Asst. M. E., Maint., Hershey Corp.

CENTRAL JARONU, Camaguey

VARONA, Miguel C. ('27; '35), Ch. Engr., Maint., Am. Sugar Refining Co.

CENTRAL PRESTON, Oriente

SANTAMARIA, I. J. (J'29), Asst. Engr., Oper. & Maint. United Fruit Co., Central Preston, Oriente; *for mail,* Apartado 8, Havana.

FRANCISCO, Camagüey

CRAWLEY, Geo. E. ('08; '28), Gen. Mgr., Francisco Sugar Co.

GUANTANAMO, Oriente

BARRON, Edmund W. ('21), Ch. Engr., Guantanamo Sugar Co.

HAVANA, Havana

DALLAS, Chas. F. ('19), Mgr., Treas., Antillan Constr. Co., Edificio Horter 414, Calle Obispo 7.
DE GOIRIGOLZARRI, Manuel (A'18), Cons. Engr., Calle 21, 330, Vedado.
ESTRADA, Esteban Duque ('93), Ch. Engr., Personnel Sec., Dept. Pub. Wks.; *for mail,* Calabazar.
ESTRADA, Ralph ('36), Cia. Azucarera Atlantica del Golfo, Edificio La Metropolitana.
FANJUL, H. Chas. (J'35), Asst. Mgr., Cespedes Sugar Co., Central Cespedes, Camagüey; *home address,* Edificio La Metropolitana, Havana.
GOWLING, Lawrence R. ('20; '35), M. E., Cia. Cubana de Electricidad, Monte 1, P. O. Box 1715.
MARTEL, F. Antonio (J'28), Calle B 212, Vedado.
McMILLAN, Chas. E. ('22), Partner, Woodward, McMillan & Co., Edificio La Metropolitana.
MILLER, Edw. Godfrey ('13; '13; '35), V. P., Gen. Mgr., Cia. Azucarera Atlantica del Golfo, P. O. Box 69.
MULLINS, Edw. E. ('19), M. E., Charge Maint., Sinclair Cuba Oil Co., S. A., Aguiar St. 75.
NICOLAI, Gustav ('24), 36 Calle C, Rep. Jes. Maria, Marianao.
OLIVER, C. B. ('36), Supt. of Prod., Cia-Cubana de Electricidad, Monte 1.
PUIG, Ignacio F. (J'34), 53 Concepcion, Vibara.
RAE, John ('34; '35), Supt., Cuban Portland Cement Corp., Havana; *for mail,* Cayo Mason, Pinar del Rio.
ROMANACH, Juan A. ('23; '35), Supt. Hyd. Serv. & Equip., United Rys. of Havana; *for mail,* 44 Lugareno St., Ensanche.
ROMERO, Cirilo ('18; '25; '35), Langunas 27, Altos.
SKILTON, Harry Ingersoll ('25), Owner, H. I. Skilton, Sugar Mill Equip., Tejadillo 1.
STUNTZ, John Edw. ('03; '16), Life Member; Cons. Engr., Design & Opera., Cane Sugar Factories, 414 Edificio Horter.
WALES, Robt. ('36), Ch. Engr., Supervision Boiler & Mchy. Ins. & Inspc., Cia. Cubana de Fianzas, Amargura 23, Altos.

MIRANDA, Oriente

KOCH, Edw. G. ('26; '35), Gen. Mgr., Warner Sugar Corp.

PERICO, Matanzas

HIGGINBOTHAM, Oscar ('26; '33), Ch. Engr., Cia. Ingenios Azucareros Matanzas, S. A., Central España.

QUEMADO de GUINES, Santa Clara

LANIER, H. D. ('36), Gen. Supt. & Cons. Engr., Gen. Sugar Co., 20 Exchange Pl., New York, N. Y.; *for mail,* Central San Isidro, Apt. 39.

SAGUA la GRANDE, Santa Clara

MACFARLANE, Jas. ('08), Pres. & Gen. Mgr., Macfarlane Fdy. & Honolulu Iron Wks., S. A., P. O. Box 43.

SAN GERMAN, Oriente

GIANELLONI, Vivian J. ('17; '19; '24), Mgr., Fidelity Sugar Co.

SENADO, Camagüey

DIAZ-COMPAIN, Jeronimo ('25; '32), Ch. Engr., Central Senado.

DOMINICAN REPUBLIC

BARAHONA

KENNEDY, Douglas P. ('28), Gen. Factory Supt., Barahona Co. Inc.

LA ROMANA

GERRISH, L. M. ('28), Ch. Engr., Central Romana, Inc.
KLOCK, Ernest L. ('17), Mgr., Central Romana, Inc.

TRUJILLO (Santo Domingo)

DAVIDSON, Wm. Harold ('20; '24), Exec. V. P., Compania Electrica.

JAMAICA

MONTEGO BAY

EWEN, Rupert L. ('24; '32), Mgr., Hotel Casa Blanca.

PUERTO RICO

See Page 147

TRINIDAD

POINTE-A-PIERRE

AP RHYS PRYCE, Mervyn A. ('30; '33; '35), Ch. Petroleum Engr., Trinidad Leaseholds, Ltd.

SOUTH AMERICA

ARGENTINA

ALTA-GRACIA

OLDITCH, Fred'k W. ('17) Tech. Adviser, Ministerio Obras Publicas, Comision Especial, Estudio Concesiones Electricas; *for mail,* Las Higueritas, Alta-Gracia, F. C. C. A.. Provincia de Cordoba.

BUENOS AIRES

ARNERICH, Paul Frank (J'32), Instr., Math. & Physics, Colegio Americano, Rivadavia 6100.
AUSTIN, Geo. H. ('34), Mgr., Ch. Engr., Prov. of Buenos Aires Water Wks. Co., Ameghino 870, Avellaneda.
BARKER, Herbert ('34; '35), Charge Fine Spinning Sec., Manufactura Algodomera Argentina, S. A., Alvarez Thomas 200.
BECKWITH, Bernard L. ('27; '35), Mgr., Indus. Mchy. Dept., Gen. Elec. S. A., Av. R. Saenz Peña 636.
DIAZ, Enrique ('27; '35), Gen. Elec. S. A., Av. R. Saenz Peña 636; *for mail,* Chacabuco 1390.
DIEDRICHS, German Carlos (J'28), c/o G. A. Rappard, San Martin 232.
GALLOWAY, Frank M. ('21; '27), M. P. Rep., Frigorifico Armour de la Plata, Reconquista 314.
HANUŠ, Francis J. ('30; '35), Engr., Charge Local Representation, Soc. An. Autes Establicimientos SKODA, 832 Diagonal Norte.
IRWIN, Vincent H. ('21; '35), Engr., Power Div., E. I. du Pont de Nemours & Co., Wilmington, Del.; *for mail,* c/o Stanley Reeves, Ducilo S. A., Av. R. Saenz Peña 832.
JUDY, Wilbur H. ('16; '35), Owner, Talleres & Fundicion "Volcan," Aristobulo del Valle 1480.
KNUDSEN, Knud Vendelbo ('21), Ch. M. E., F. F. C. C. del Estado, San Jose 180; *for mail,* Calle Uruguay 888.
LLANSO, Joaquin (J'29), Mgr. for the Argentine, Paraguay & Uruguay, Worthington Pump & Mchy. Corp., Harrison, N. J.; *for mail,* Casilla de Correos 1677, Buenos Aires, Argentina, S. A.
MELROSE, R. G. R. ('29), Lub. Serv. Engr., Galena Signal Oil Co., S. A., Sarmiento 470.
PODNOSSOFF, Jules (J'31), *Charles T. Main Award,* '30; *Student Award,* '31; Commercial Refrig. Engr., Gen. Elec. S. A., Diagonal Norte 636; *for mail,* Bartolomé Mitre 2121.

MARMOL

KRAUSE, Karl H. (J'27), Massey-Harris Co., Ltd., Marmol F. C. S.

TUCUMAN

VILLASUSO, Armando S. ('22; '23; '35), Tech. Dir., Cia. Azucarera Concepcion; *for mail,* Ingenio Concepcion.

BRAZIL

BAURU

ADAMS, Herbert B., Jr. (J'30), Supt., Bauru Mill, Anderson Clayton & Co., Ltda., Caixa Postal 2992, São Paulo; *for mail,* Anderson Clayton & Co., Ltda., Caixa Postal 23, Bauru.

CAMPINAS

HAILE, Wm. A., Jr. ('36), Rua Barao de Jaguara, 1357, Campinas (Est. de São Paulo).

PERNAMBUCO

GAUSMANN, Robt. W. (J'28), Pernambuco Tramway & Power Co.

RECIFE (Pernambuco)

BANKS, Jos. Turney ('32; '35), Sales Engr., Internatl. Mchy. Co., Caixa Postal 9.
DE QUEIROZ, Joel A. (J'35), Rua Conde de Boa Vista, 746.

RIO DE JANEIRO

BAYNTUN, Robt. S. ('27), Empresas Electricas Brazileiras.
LEE, Wallace R. ('13), V. P., Charge Sales in Argentina, Brazil & Uruguay, Gregg Car Co., Ltd., 19 Rector St., New York, N. Y.; *for mail,* Caixa Postal 1492, Rio de Janeiro, Brazil, S. A.
LESLIE, Herbert ('20; '25), Ch. Engr., Stand. Oil Co. of Brazil, Caixa Postal 970.
NEIVA, Lt. Rubens V. (J'36), Naval Officer, Ministerio da Marinha; *for mail,* Rua Domicio da Gama, 19.
O'CALLAGHAN, John (J'25), Cia. Nacional de Cimento Portland, Caixa Postal 257.

SÃO PAULO

BILLINGS, A. W. K. ('09), Life Member; V. P., Charge Engrg. & Constr., Brazilian Traction, Light & Power Co., Ltd., 25 King St., W., Toronto, 2, Ont., Can.; *for mail,* 1658 Avenida Brasil, São Paulo, Brazil, S. A.
FELTEN, Jos. M. ('27), Engr., Charge Design, Cia. Nitro Chimica Brasileira, São Miquel; *for mail,* Rua Augusta 2653.
HAAG, Paul H. ('23; '25; '30), M. E., São Paulo Tramway Light & Power Co., Ltd.
SIGRIST, Herman ('22; '27), M. E., São Paulo Tramway Light & Power Co., Ltd., Caixa Postal "a."

CHILE

CHAÑARAL

HOFFMAN, Ralph N. ('21; '35), Andes Copper Min. Co.
PYSTER, J. N. (A'19), Ch. Engr., Andes Copper Min. Co., Chañaral (Barquito).

CHUQUICAMATA

GWYNNE, Guy R. ('29), M. M., Chile Exploration Co.
HEITZ, Robt. L. (J'32), Engr., Maint., Chile Exploration Co.
WHEELER, Burr ('18), Gen. Mgr., Chile Exploration Co.

RANCAGUA

BROEKER, Fred'k G. ('17; '35), Engr., Charge Shops & Fdy., Braden Copper Co.
HANSEN, Carl M. ('14), M. E., Braden Copper Co.
HANSEN, Carl Magnus (J'28), M. E., Braden Copper Co.

SANTIAGO

KRUGER, Paul F. ('22), Gen. Mgr., Cia. Salitrera Anglo-Chilena, Cassilla 96-D, Santiago; *for mail,* Casilla 17, Tocopilla.

TOCOPILLA

BOYNTON, Arthur L. ('28), Res. Engr. in Tocopilla, Chile, S. A., for Chile Exporation Co., 25 Broadway, New York, N. Y.
GAREY, Geo. W. ('22; '35), Ch. Engr., Cia. Salitrera Anglo-Chilena, Casilla 17.

COLOMBIA

BARRANCA-BERMEJA

FARNHAM, D. W. (J'34), Asst. Supt., Natural Gas & Gasoline Dept., Tropical Oil Co.
HURT, R. M. (J'34), Ch. Petroleum Engr., Tropical Oil Co.
McSWEENEY, Wm. T. ('31; '35; '36), Ch. Engr., Power Plant, Tropical Oil Co.
ZWICK, Ben F. (J'32), Asst. Prod. Supt., Tropical Oil Co.

BARRANQUILLA

DALRYMPLE, Arthur W. ('23; '34), Supt. Prod., Cia Colombiana de Electricidad, Apartado Postal 739.
FOULDS, Chas. V. ('19; '30), Hyd. Engr., Pato Consltd. Gold Dredging, Ltd., Apartado 819.

BOGOTA

CORTES, Jos. M. ('23; '31; '35), Asst. Mgr. & Cons. Engr., Cia. Molinera de Tundama, P. O. Box 1007.
FERRIS, Randall ('25), Instr., Motive Power Sec., Natl. R. R. of Colombia, Bogota; *for mail*, Apartado 23, Cali.

CARTAGENA

JAREMA, John D. (J'26), M. E., Andian Natl. Corp. Ltd., Apartado 130.
KLINTMAN, P. C. ('29; '35), Charge Maint. of Internal Combustion Engines, Andian, Natl. Corp. Ltd., Apartado 130.

FRONTINO

FLOWER, Henry R. ('29), Frontino Gold Mines, Frontino, Antioquia.

MADRID

LASERNA, Alfonso (J'35), Prof. of Mechanics, Base aérea Madrid, Madrid, Cundinamarca; *for mail*, Calle 15, No. 8-05, Bogota.

PUERTO BERRIO

RIPPE, Carlos (J'35), M. E., Ch. Shops, Astilleros y Talleres Nacionales de Sta. Cruz.

PERU

LIMA

GALLESE, Julio J. (J'33), Cons. Engr., Plaza San martin 158-162; *for mail*, Casilla 317.
GRIEVE, Albert ('15; '35), Prof. Mch. Design, Lima Sch. Min. Engrs.; Municipal E. E., City of Lima; Owner, Factoria y Garage; *for mail*, Apartado 615.

URUGUAY

MONTEVIDEO

ANDERSON, Einar F. ('30; '35), Cia. Uruguaya de Cemento Portland, Zabala 1338.

VENEZUELA

CAMPITA

MITCHELL, John C. W. ('33; '34; '35), Stand. Oil Co.

CARACAS

TURCO, Leopoldo (J'33), M. E., Mchy. Dept., Govt. Public Wks.; *for mail*, Oeste 10, No. 69.

CARIPITO

JOHNSEN, Geo. John (J'33), Mech. Designer, Stand. Oil Co. of Venezuela.
KAHLE, Loren F. (J'29), Ch. Engr., Stand. Oil Co. of Venezuela.

MARACAIBO

BRIELL, Theodore, Jr. (J'34), Venezuelan Gulf Oil Co., Apartado 234.
JORDAN, Leland T. (J'29), Apartado 234.
RIGGS, Harold E. ('27), Supt., Power Prod., Venezuela Power Co., Apartado 146.
SHEA, Francis X. (J'36), c/o Venezuelan Gulf Oil Co., Cabinas; *for mail*, Apartado 234.

AFRICA

MOROCCO

CASABLANCA

WEIR, Thos. A. (J'28), Engr. Fuels, Socony-Vacuum Oil Co., Inc., 20 Rue de L'Horloge, Casablanca, Morocco, Africa; *for mail*, 54, Rue de Londres, Paris, 8e, France.

EGYPT

CAIRO

MEYER, Harold F. (J'23), Engr., Vacuum Oil Co.

UNION OF SOUTH AFRICA

CAPE TOWN, Cape of Good Hope

BENNING, Victor Leopold ('22; '32; '35), Charge Engr., Electricity Supply Comm., Salt River Power Sta., Dock Rd.; *for mail*, "Het Loo," Bennington Rd.

EAST LONDON, Cape of Good Hope

TANKARD, Donald W. ('32; '35), Lecturer, Technical College, Lukin Rd.

GERMISTON, Transvaal

WADE, Walter A. ('30; '34), Inspr. of Mchy., Mines Dept., Govt. of Union of S. Africa; *for mail*, Germiston.

JOHANNESBURG, Transvaal

ALLEN, Maj. Michael H. P. ('34), Dir. & Gen. Mgr., Bell's Asbestos & Engrg. (Africa) Ltd., 100 President St.
BATEMAN, Edw. L. (A'97), Gen. Mgr., Edw. L. Bateman (Pty) Ltd., P. O. Box 1671.
COTTERELL, Wm. J. ('24), Managing Dir., Internatl. Combustion, Ltd., P. O. Box 5981.
ORR, John ('09), Prof. Engrg., Witwatersrand Tech. College, Eloff St.
REUNERT, Theodore ('01), Chmn., Renuert & Lenz, Ltd., P. O. Box 92.

MUIZENBERG, Cape of Good Hope

WILLIAMS, Alpheus F. (A'00), Ver Genoeg.

VEREENIGING, Transvaal

LUBBE, Wilhelm ('33; '35), Ch. Draftsman, Union Steel Corp. of S. Africa, Ltd., Box 48.

ASIA

CHINA

CANTON

BROWN, Carl G. ('20; '26; '35), Victoria Hotel, Shameen.
CARNEGIE, Jas., Jr. ('17; '35), Gen. Supt., Kwangtung Elec. Supply Co.
LEE, Chun C. ('33; '35), Commissioner, Dept. of Pub. Utilities, Canton Municipality.

CHENGCHOW, Honan

KAO, Si Chin (J'32), Loco. Dept., Lung-Hai Ry. Admin.

HONG KONG

UN, Kwok-Ping (J'32), Engr., Oper. & Maint., Waiyeung Sugar Central, Pingtam, Waiyeung, Kwangtung; *for mail*, 20 Somerset Rd., Kowloon Tong, Hong Kong.

NANKING

HOU, Te Pang ('22; '35), Wks. Mgr. & Engr.-in-Ch., Yungli Chem. Industries, Ltd., 40 Hsien Yu Hsiang, Hsiakwan.

PEIPING

CHWANG, Chien-Ting (J'27), Dean, M. E. Dept., Natl. Tsinghua Univ.
LEE, Yosan (J'30), P. O. Box 38.
SU, N. (J'35), 42 Chi Chih Wei.

SHANGHAI

CHEN, Wiley C. (J'36), 22 Jessfield Villa, Brenan Rd.
COUCH, David H. ('19), Plant Betterment Engr., Shanghai Power Co., 181 Nanking Rd.
HARVEY, Albert H. ('32), Inniss & Riddle (China) Ltd., 34, Yuen Ming Yuen Rd.
HOECKEL, Rolf H. ('28), Charge Mech. Sec., Arnhold & Co., Ltd., Sassoon House, 1 Nanking Rd.
JOURDIN, Willis W. ('12), Generation Engr., Shanghai Power Co., Box 404.
LEM, Frank Yee ('27; '34; '35), Jr. Asst. Engr., Shanghai Power Co., 95 Nanking Rd.; *for mail*, House 2, Lane 18, Jessfield Rd.
STUART, Thos. C. (J'30), Natl. Carbon Co., Fed. U. S. A., 248 Yangtzepoo Rd.
WU, King Ching (J'29), Assoc. Prof., Applied Mechanics & Hyds., Natl. Chekiang Univ., College of Engrg., Hangchow; *for mail*, 88 Ming Tch Lee, Foch Ave., Shanghai.

TANGKU, Hopei

LEE, Gilmer T. ('16), Adviser to Pres., Pacific Alkali Co., Ltd.

TIENTSIN

KWANG, Kwong Yung ('99), Life Member; 39 Race Course Rd., British Concession.

WUCHANG

GILMAN, Fred'k C. (J'29), Central China College.

FEDERATED MALAY STATES

See Malay Peninsula, Page 163

INDIA

AHMEDABAD, Bombay

BABAYCON, M. A. ('33), Ch. Engr., Asoka Mills, Ltd.; *for mail*, Asoka Bungalow, Naroda Rd.
THAKER, S. H. ('21; '35), Inspc. of Steam Boilers & Smoke Nuisances, Govt. Bungalow 6b, Shahibag.
VYAS, M. M. ('31; '35), Ch. Engr., Maneklal Harilal Mills, Railwaypura Post. Ahmedabad 2.
WADIA, A. D. ('12), Merchant, A. D. Wadia & Sons, Kankaria Rd.; *for mail*, Wadia Villa.

BAGAHA, Champaran, Bihar

BERGMAN, Carl A. ('15), Naraipore, P. O. Bagaha, Bengal & North-Western Ry.

BANGALORE, Mysore

CHETTY, B. Krishnaswamy ('32; '35), Tech. Asst. Mysore Govt. Ptg. Office.
MUTHUSWAMI, S. ('29; '35), Asst. Prof. M. E., College of Engrg.
RAMASWAMI, E. K. ('29), Prof. M. E., College of Engrg.

BARODA, Baroda

AGASHE, K. M. (J'36), Foreman, Charge Design & Execution, Huzur Pub. Wks. Dept., Kothi Rd.; *for mail*, Khari Wao Rd.
PATEL, Chimanbhai M. ('29; '35), Boring & M. E., P. W. D., Baroda State, Race Course Rd.

BHADRAVATI, Mysore

CHANNAPPA, Bangalore Kenchappa ('30; '31; '35), Gen. Foreman, Charge Mch. Shop, Mysore Iron & Steel Wks.
GOPALAKRISHNA, S. ('26; '35), Ch. Draftsman, Mysore Iron Wks., Bhadravati; *for mail*, No. 14, Model Houses, Bangalore City.
KRISHNAMURTHY, B. S. ('28; '35), M. E., Charge Maint., Mysore Iron & Steel Wks.; *for mail*, New Town.

BOMBAY, Bombay

HASKELL, M. E. ('32), Indus. Engr., Govt. Dept. of Industries Old Custom House.

MASTER, J. N. ('24; '35), Hirji Mansion, Cumballa Hill.
NIMBKAR, Vishnu (J'27), Mgr. & Engr., Consltd. Pneumatic Tool Co., Ltd., P. O. Box 335.
RAO, M. K. (J'33), Field Engr., Bedaux Co. of India, 9 Rampart Row; *for mail*, Casa Bianca, Mahim.

CALCUTTA, Bengal
BENTLEY, Harold ('30), Gen. Mgr., Keymer, Bagshawe & Co., Ltd., Sassoon House, 4, Lyons Range.
DHAR, Matilal ('25; '34; '35), Dhar Co., Engrs. & ..., Importers, 84-A Clive St.
KHOSLA, R. K. ('26), Govt. Inspr., Indian Stores Dept., 6 Esplanade; *for mail*, 81 Lansdown Rd.

CHHEHARTA, Amritsar, Punjab
SINGH, Jagir (J'34), Engr., c/o Khazan Singh Esq., c/o Modern Industries, Ltd.

DELHI, Delhi
CASE, Robt. C. ('24; '35), Deputy Ch. Controller (Standardization), Ry.
SACHDEV, Mohan Lall ('34; '35), Supt., Workshop, Delhi Municipal Com.

DHANUSHKODI, Madras
SAUNDARARAJAN, A. ('29; '35), 2nd Engr., T. S. S. Irwin.

DICHKOT, Lyallpur, Punjab
PATHAK, Mukand L. ('25), Dichkot P. O., Dist. Lyallpur.

GOLMURI, Orissa
BASAN, Bhagat R. ('31; '35), M. M., Agrico, P. O. Golmuri, Via Tatanagar, Bengal Nagpur Ry.

GULAB-BARI, Ajmer
SHARMA, O. N. (J'34), Sr. Draftsman, Drawing Office, Loco. Cent. Shops, Bombay, Baroda & Cent. India Ry.; *for mail*, Madar ka naka.

HINDUPUR, Madras
RAO, K. N. (J'30), Elec. Engr., Municipal Council.

JAMSHEDPUR, Bihar and Orissa
BOSE, Surandra Nath ('26), Ch. E. E., Maint. & Design, Tata Iron & Steel Co., Ltd.; *for mail*, 5 Office Rd.
BURGESS, R. M. ('30; '35), Asst. Gen. M. M., Tata Iron & Steel Co., Ltd.; *for mail*, 4 Office Rd.
LELE, R. N. ('22; '26; '35), Estimating & Planning Engr., Tata Iron & Steel Co., Ltd.; *for mail*, 21 E. Road East, Jamshedpur, via Tatanagar, Bengal Nagpur Ry.
MURTY, T. B. N. ('27; '35), Designer, Tata Iron & Steel Co., Ltd., Jamshedpur; Cons. Engr., Ryot's Agric. Implements Co., Tanuku; *for mail*, 23 H-6, Jamshedpur.
RAJU, C. S. N. ('27; '34; '35), Asst. Power Engr., Tata Iron & Steel Co., Ltd.; *for mail*, 1 Beldih Triangle.
SINHA, Jaimangal ('28; '32; '35), M. E., Plant Maint., Tata Iron & Steel Co., Ltd.; *for mail*, 16 Hill View Rd.

KARACHI, Sind, Bombay
BHAPPU, Kavasji K. ('21; '35), Life Member; Managing Partner, Crystal Ice & Cold Storage Co., Kutchery Rd.
HILTON, Eric A. ('26), Supt. Mchy., Municipal Corp., Lawrence Rd.; *for mail*, Markwick Rd.

KIRLOSKARVADI, Satara
KIRLOSKAR, S. L. (J'27) Deputy Gen. Mgr., Kirloskar Bros., Ltd.

LAHORE, Punjab
CHAWLA, S. H. ('33), 6 Beadon Rd.
GABLA, Pestonji F. ('28; '35), Inspr., Oil Engines for Power House, North-Western Ry.; *for mail*, c/o E. M. Desai, Esq., 15 Beadon Rd.
SINGH, Inder ('28), Ch. Inspr. Boilers, Govt. of Punjab; *for mail*, 9 Temple Rd.

LUCKNOW, United Provinces
SARDANA, Amar Nath (J'35), c/o M. G. Sardana, Irrigation Secreteriate.

MANDYA, Mysore
FENNING, C. J. H. ('21), Mgr., Mysore Sugar Co., Ltd.

MATUNGA, Bombay
BURLEY, G. W. ('26), Prof. M. E., Victoria Jubilee Tech. Inst.

MOGHALPURA, Lahore
BHATNAGAR, Jagdish Narain ('30; '32; '35), Asst. Demonstrator, Maclagan Engrg. College.

NARAYANGANJ, Bengal
MEHTA, T. C. ('35; '35), Water Wks. Engr., Narayanganj Water Wks.

PAREL, Bombay
CLARKE, C. W. ('35; '35), Asst. M. E., C. M. E. Dept., Great Indian Peninsula Ry.
DA COSTA, Gerson (J'31), Dynamometer Car Officer, Great Indian Peninsula Ry.

PHILLAUR, Jullundur, Punjab
SINGH, Nand ('16; '18; '23), Cons. Indus. Engr.

SIMLA, Punjab
BOSE, Kumudini Kanta ('18; A'22), Deputy Director of Purchase, Indian Stores Dept., New Delhi St.

TRICHUR, Cochin, Madras
MENON, V. K. A. ('23; '33; '35), Chief Engr., Cochin State.

UJJAIN, Gwalior, Central India
RAM, R. Anant, Sr. ('30; '34; '35), Hira Mills, Ltd.

VIZIANAGRAM, Madras
RAO, B. L. (J'36), Electrician, Charge Elec., Dept., Maint., Vizianagram Estate, Fort St.; *for mail*, Voruganti St.

WALTAIR, Madras
LAZARUS, Reginald L. ('29; '35), Inspr. Steam Boilers, Govt. of Madras, Madras; *for mail*, Sunnyside, Waltair.

JAPAN

HIOGO-KEN
KUWADA, Gompei ('00), Pres., Nihon Spindle Seizosho; *for mail*, Odamura Shiwoye Kawabegun.

KYOTO
ISHIMURA, Lyuho S. ('17; '21; '35), Life Member; Exec. Pat. Engr., Nippon Denchi Kabushiki Kaisha, Shinmachi, Imadegana.

KURE CITY, Hiroshima-Ken
KATO, Yoshio ('30), Engr. Commdr., I. J. N., Kure-Kaigun-Kosho, Zokibu.

TOKYO
ABE, Keiichi ('20), Mitsubishi Jūkōgyō Kabushiki Kaisha, Ltd., 4, Marunouchi 2.
ENZ, Karl A. ('20), Cons. Engr., 17 of 14, Shiba Park.
GORHAM, Wm. R. ('12; '21; '35), Managing Dir. Engrg., Kokusan Seika Kaisha, Ltd., 17 Shimbashi-Machi, Shibuya-Ku; *for mail*, 15 of 126 Kamimeguro.
KAMO, Masawo ('25; H'29), Prof. M. E., Tokyo Imperial Univ.
MACGREGOR, D. D., ('30), V. P., Charge Mfg. & Engrg., Mitsubishi Oil Co. Ltd., Yaesu Bldg., Marunouchi; *for mail*, Cent. P. O., Box 154.
RABBITT, Jas. A. ('19), Dir., Japan Nickel Information Bur.; Cons. Engr., Internatl. Nickel Co., Inc., New York, N. Y.; *for mail*, c/o Japan Nickel Information Bur., Shisei Kaikan, Hibiya Park, Tokyo, Japan.
SEKIGUCHI, Y. ('23), Prof. M. E., Tokyo Univ. of Engrg., Okayama, Megroku; *for mail*, 60 Gotanda 5 Chome Shinagawaku.
SHIMA, Yasuziro ('23), Cons. Engr., 45 Takanawa Minamimachi, Shibaku.
TAKEO, Toshisuke ('08), Pres., Karatsu Iron Wks., Karatsu, Saga-Ken; *for mail*, 50 Yakuojimachi, Ushigomeku.
THOMAS, Fred S. ('24), Engrg. Rep. for the Orient, Westinghouse Air Brake Co., Pittsburgh, Pa.; *for mail*, 665 Marunouchi Bldg., Tokyo, Japan.
WARNER, R. F., Jr. (J'33), c/o Fujita & Warner, 321 Yaesu Bldg, Marunouchi.

YOKOHAMA
HASHIMOTO, Shinsuke ('26; '35), M. E., Mgr., Ohi Wks., Japanese Govt. Rys., Tokyo; *for mail*, 48 Tan-machi, Kanagawa-ku, Yokohama.

YOKOSUKA CITY, Kanagawa-Ken
YOSHINARI, M., ('30), Rear-Admiral, I. J. N., c/o Yokosuka Kaigun Kosyo Zokibu.

MALAY PENINSULA

IPOH, Perak, Federated Malay States
LOVELL, Wm. Douglas ('32), Deputy Ch. Engr., Perak River Hydro. Elec. Power Co., Ltd., P. O. Box 109.

SINGAPORE, Straits Settlements
AARON, H. Richard ('22; '26; '35), Prop., Malayan Mech. Equip. Co., 6 Raffles Pl.
FAXON, H. C. ('36), Engineer, Borneo Co., Ltd., Engrg. Dept.

PALESTINE

HAIFA
KURREIN, Max ('34), Prof. M. E., Head of Workshops, Technion, P. O. Box 910; *for mail*, P. O. Box 955.

SIAM

BANGKOK
THITHAN, Kling ('25; '31; '35), 569 Rear Lane Petburi School, Petburi Rd.

STRAITS SETTLEMENTS

See Malay Peninsula, This Column, Above

SYRIA

BEIRUT
TABIT, Aziz J. ('30), Am. Univ. of Beirut.

AUSTRALASIA

Australia. See Page 167
New Zealand. See Page 167

EUROPE

AUSTRIA

VIENNA
BRUCKMANN, Hugo ('27; '35), Cons. Engr., Dianagasse 2, Vienna III.

BELGIUM

ANTWERP
HEWITT, Reginald Wm. (J'27), Tools, Rates, Methods & Maint., Automotique Elec. de Belgique, 22 rue du Verger.

BRUSSELS
DE SMAELE, Albert ('30; '35), Sous-Dir., Charge Mgmt., Electrobel, 1 Place du Trone; *for mail*, 17 Place Georges Brugmann.
MESSENGER, Robt. P. ('13; '31), Inspr. Gen. of Exper., Internatl. Harvester Co., 1 Place Stephanie.
SCHLESINGER, Georg ('05), Prof. Engrg., University of Brussels, 12 Place Georges Brugmann.

CZECHOSLOVAKIA

PRAGUE
MUZIK, Victor Klifton ('24; '30; '35), Directing Engr., Tech. Mgr., Motor Co., Voctářova, Prague VIII; *for mail*, Prague-Nusle 1.
NEBESAR, Robt. J. ('28; '35), Ch. Engr., Charge Design, AVIA Aircraft Corp., Prague-Cakovice; *for mail*, Obvodova 6.
ORENSTEIN, H. ('22), Cons. Engr., 37, Prikopy.

PUC, Vojtech ('21; '35), Partner, Waldes & Co., Vrsovice; *for mail,* Vinohrady, Mirove n. 18, Prague XIII.
SLECHTA, Emanuel ('23; '25; '35), Cons. Engr., Lazarská 7, Prague II; *for mail,* Zizkov 223, Kutna Hora.
ŽENATÝ, Bert ('28; '35), Mgr. Sales Promotion Dept., Iron & Steel Wks., Lutzowova 55, Prague XIX.

STARA BOLESLAV

ZEHR, Vratislav A. ('19; '25), Cons. Engr.

DENMARK

COPENHAGEN

BAK, Anders Kristian ('20; '25), Supt. Opera., Copenhagen Lighting Dept., 8 Vognmagergade; *for mail,* C. R. Richsvej 23, Copenhagen F.
JENSEN, S. Valeur ('31), Engr., Charge Design, F. L. Smidth & Co., Vestergade 33.
SKULE, Jorgen C. J. ('35), Tech. Dir., Berlingske Tidende; *for mail,* Hammerensgade 1.
STOCKEL, Frants C. ('24), Cons. Engr., Designer, 38 Mollegade.

ESBJERG

LARSEN, Harry E. ('23; '35), De Forenede Isvaerk.

FAABORG

ESKELUND, A. A. Kai ('29; '35; '35), I/s. Maskinfabriken "Justa," Østergade 45.

HOLBAEK

PETERSEN, P. Jansen ('19; '27), Holbaek Maskinfabrik; *for mail,* Villa Alleruphoj, Allerup pr.

ENGLAND

ACCRINGTON, Lancashire

KENYON, Jas. M. (J'35), Asst., Devel. & Research Dept., Glenfield & Kennedy, Ltd.; *for mail,* "Waterloo," Whalley Rd., Accrington, Lancashire, Eng.

AVONCROFT, York

BEALING, Ernest ('36), North Eastern Dist. Engr. & Rep., Messrs. Spencer (Melksham) Ltd., Melksham, Wilts; *for mail,* Avoncroft, Dringhouses, York.

BATH, Somerset

PENRUDDOCKE, J. H. ('89), Retired; Ensleigh, Limpley-Stoke.

BIRMINGHAM, Warwick

MACLAREN, Jas. E. ('30; '35), Branch Mgr., Buck & Hickman, Ltd., 30 Whittall St.
ORCUTT, Harry F. L. ('00), Managing Dir., Gear Grinding Co., Ltd., Anne Rd., Handsworth, Birmingham; *for mail,* Rowington Hall, near Warwick.
ROBY, C. F. ('22; '26; '35), Managing Dir., Cincinnati Milling Machines, Ltd., Woodlands Farm Rd., Tyburn.

BOURNEMOUTH, Hampshire

VICKESS, Samuel ('01), Cons. Engr., Clarewood, Chessel Ave.

COVENTRY, Warwick

DOUGLAS, John R. ('31), Ch. Constr. Engr., Courtauld's, Ltd.; *for mail,* 3 St. Paul's Rd.

DAGENHAM, Essex

HALER, P. J. ('20), Principal, South East Essex Tech. College, Longbridge Rd.

DUDLEY, Worcester

OPIE, Ernest J. ('28), Gen. Mgr., Louis Marx & Co., Ltd., Waddams Pool Wks.

FRINTON-ON-SEA, Essex

SCOTT-TAGGART, John ('35), Cons. Engr., Harlow Labs.

GATLEY, Cheshire

LISTER, Robt. R. ('94), Life Member; Governing Dir., Greenbank Laundry, Ltd., Old Hall Rd., Gatley; *for mail,* 3 Milton Crescent, Cheadle.

HALIFAX, York

VARLEY, G. ('30), Asst. to Managing Dir., Wm. Asquith, Ltd., Halifax; *for mail,* 95 New North Rd., Huddersfield.

HEXTABLE, Kent

GILLER, Frederick Stanley ('13; '23), Cons. Engr., "Fairseat."

LAPWORTH, Warwick

ORCUTT, A. H. ('36), Gen. Managing Dir., Gear Grinding Co., Ltd., Anne Rd., Handsworth, Birmingham; *for mail,* "Oakfield," Lapworth.

LEICESTER, Leicester

RITCHIE, Albert P. ('24; '35), Managing Dir., Taylor Mchy. Co., Ltd., Grange Lane.

LONDON

ALLINGHAM, Henry Wm. ('16), 10 Stratford Pl., W. 1.
ANDERSON, Nils H. ('32; '35), F. R. Raper Co., Ltd., 35 Garrett Lane, Wandsworth, London, S. W. 18; *for mail,* 27 Litchfield Court, Richmond, Surrey.
ANDREWS, Henry Ivan (J'29), Research Dept., London, Midland & Scottish Ry. Co., Euston Sta., N. W. 1.
BONSTOW, Thos. L. ('21), Whitehall Securities Corp., 47, Parliament St., S. W. 1.
BROWNLIE, David ('21), Cons. Tech. Chemist, 46 Grange Rd., Ealing, W. 5.
BRUCE, Archibald K. ('27), Partner, Robert Bruce & Sons, Moorgate Hall, Moorgate, E. C. 2.
CAMERON, Archibald P. ('19), Mgr., Water Wks. Dept., Worthington Simpson, Ltd., Queens House, Kingsway, W. C. 2.
CARROLL, Lafayette D. ('88), Life Member; M. E., Humphreys & Glasgow, Ltd., Humglas House, Carlisle Pl. & St. Francis St., Victoria, S. W. 1.
CHAMPION, C. H. ('33), Managing Dir., Ship Carbon Co. of Great Britain; *for mail,* 60 Wardour St.
CHESTER, Thos. ('15), Mgr., Air Conditioning Dept., Davidson & Co., Ltd., Central House, Kingsway.
CHRISTENSEN, Wm. P. ('21; '26), Chmn., Com. on Products, Crane, Ltd., 45-51 Leman St., London, England; Cie Crane, 96 Blvd. Richard Lenoir, Paris, France (*former address for mail*).
DEAN, E. Stanley ('30; '35), Asst. Sales Mgr., Richardson's-Westgarth-Brown Boveri, Ltd., 56 Victoria St., S. W. 1.
GARRATT, Ernest A. ('07), Dir., Jacobs Barringer & Garratt, Ltd., 37 Fenchurch St., London, E. C. 3; *for mail,* Crow's-Nest, Pear Tree Lane, Shorne, Kent.
GEER, Henry E. ('31), Ch. Engr., Superheater Co., Ltd., Bush House, Aldwych, W. C. 2.
GLASGOW, Arthur Graham ('92), Life Member; Chmn., Humphreys & Glasgow, Ltd., Humglas House, Carlisle Pl., S. W. 1.
HAGUE, C. K. F. ('32; '34), Babcock & Wilcox, Ltd., Babcock House, 30 Farringdon St., E. C. 4.
HEENAN, J. N. D. ('19; '25), Dir., Senior Economisers, Ltd., 11 Southhampton Row, W. C. 2.
HEROD, Wm. R. (J'20), Asst. to Managing Dir., Associated Elec. Indus., Ltd., Crown House, Aldwych, W. C. 2.
HORN, Freeman ('31), Intelligence Officer, British Aluminium Co., Ltd., Adelaide House, King William St., E. C. 4.
HUTTON, Gerald H. ('19), Tech. Dir., Mines Investigations, Ltd., 55-61 Moorgate, E. C. 2.
INMAN-EMERY, J. Inman ('30), Air Ministry, British Govt., Adastral House; *for mail,* 17 Stanford Court, Cornwall Gardens, S. W. 7.
JOHNSTON, K. M. ('30), Babcock & Wilcox, Ltd., Babcock House, 34 Farringdon St., E. C. 4.
MAW, Arthur E. (J'11), 48 Beverly Court, W. 4.
McGREGOR, A. Grant ('05; '12), Cons. Engr., Selection Secretariat, Ltd., Selection Trust Bldg., Mason's Ave.
MILLS, Ernest A. ('25), Ch. Engr. & Mgr., Electricity Dept., Metropolitan Borough of Hackney, 18-24, Lower Clapton Rd., Hackney, E. 5; *for mail,* 26 Bancroft Ave., E. Finchley, N. 2.
MOLLOY, F. Geo. ('28; '35), c/o Babcock & Wilcox, Ltd., Babcock House, Farringdon St., E. C. 4.
MURRAY, James O'Hara ('25), Prop., J. O'Hara Murray & Co., 66, Hatton Garden, E. C. 1.
RAPLEY, Fred'k. A. ('25; '32; '35), Ch. Asst. Buyer, Sir John Jackson, Ltd., 53 Victoria St., S. W. 1.
ROBERTS, Edw. D. ('26), Constr. Wk., Alpha Cement Co., Ltd.; *for mail,* BM/WSVN, W. C. 1.
ROBESON, A. M. ('95), 10 Clements Lane, E. C. 4.
ROBINSON, Isaac V. ('21), Departmental Mgr., British Elec. & Allied Mfrs. Assn., 36 Kingsway, W. C. 2.
RYBKIN, Ivan (J'33), Arcos, Ltd., Bush House, Aldwych, W. C. 2.
SELVEY, Wm. M. ('35), Cons. Engr., 64 Victoria St., S. W. 1.
SPARKS, Algernon C. ('26), Partner, Cons. Engrs., Sparks & Partners, Blackfriars House, New Bridge St., E. C. 4.
SPENCER, H. Wilmot ('27), 59 Palace St., Victoria St., S. W. 1.
SPRATT, H. P. (A'33), Curator of Mar. Engrg., Sci. Museum, S. W. 7.
SWAN, S. R. B. ('36), Asst. Master Engrg., Leyton Tech. College, Leyton.
TAYLOR, J. Kenneth (J'29), Asst. Editor, Railway Gazette, London; *for mail,* Burfield, Ashcombe Rd., Dorking, Surrey.
THORPE, Robt. H. ('97), 29, Buckingham Palace Mansions, S. W. 1.
THORPE, W. A. Chas. ('20), Deputy C. M. E., Indian State Rys., Retired; *for mail,* 22 Stanhope Rd., Highgate, N. 6.
TROUP, John D. ('28), Managing Editor, Steam Engineer, 90 High Holborn, W. C. 1.
TUNNADINE, John ('21), Dir., Hatfield, Perrin & Partners, Ltd., Shell-Mex House, Victoria Embankment, W. C. 2.
TWINBERROW, J. O. ('29), Sales Engr., Babcock & Wilcox, Ltd., 32 Farringdon St., London, E. C. 4; *for mail,* 17 Wendover Rd., Bromley, Kent.
USHER, Geo. C. (A'22), Managing Dir., Internalt. Combustion, Ltd., Aldwych House, Aldwych, W. C. 2.
WALLACE, Geo. W. ('23), 46 Victoria St., S. W. 1.
WHITEFORD, Jas. F. ('08), Indus. Counsellor, 87 Regent St., W. 1.
WILDING, Jas. A. ('22), Dir., J. A. Wilding & Co., Ltd., 11 Southampton Row, W. C. 1.
ZWIMPFER, Edw. Anton ('24), Ch. Hyd. Engr., Hatfield, Perrin & Partners, Ltd., Shell-Mex House 254, Victoria Embankment, W. C. 2.

MANCHESTER, Lancashire

BROWN, Arthur Geo. ('84), Life Member; Browns' Dryers, Ltd., Victoria Bldg; *for mail,* Ellerslie Oswald Rd., Chorlton-cum-Hardy.
FLEMING, A. P. M. ('28), Dir., Research & Education, Metro. Vickers Elec. Co., Trafford Park.
GUY, Henry Lewis ('30), Ch. Engr., M. E. Dept., Metropolitan Vickers Elec. Co., Trafford Park, Manchester; *for mail,* Thornhill, Hale Rd., Hale, Cheshire.
HAIGHT, Harry V. ('99; '07), Cons. Engr., Ingersoll-Rand Co., Ltd., Lyons Rd., Trafford Pk., Manchester; *for mail,* Shandon, Harboro Rd., Ashton-on-Mersey, Cheshire.
PAILIN, Geo. ('29), Dir., Ch. Engr., Ferguson Pailin, Ltd., Elec. Engrs.

NEWCASTLE-ON-TYNE, Northumberland

BROWN, Thos. Walter Falconer (J'28), Tech. Mgr., R. W. Hawthorn Leslie & Co., St. Peter's Wks.

NORTHWICH, Cheshire

THORNTON, Brian M. (J'25), Asst. Mgr., Boiler Dept., I. C. I. (Alkali), Ltd., Northwich; *for mail,* 29 Walnut Ave., Hartford.

REIGATE, Surrey

ABERCROMBIE, James H. ('01), Retired; "Rutland," West St.
VERRALL, Godfrey T. ('28; '35), 30 Beaufort Rd.

RUGBY, Warwick

CAMPBELL, Gordon M. ('06), Mfg. Engr., Internatl. Gen. Elec. Co., British Thompson-Houston Co., Ltd., Rugby; *for mail,* Stoney Thorpe Hall, Southam.
FITCHETT, Fred'k ('34), Design Engr., British Thompson-Houston Co., Ltd.; *for mail,* 25 Lawford Rd.

ST. AUSTELL, Cornwall

STANTON, A. Lennox ('22), Life Member; 15 Carlyon Rd.

SALCOMBE, South Devon

BALDWIN, Oscar H. ('89), "Fairmont."

SHEFFIELD, York

SOUTHERN, Gilbert Wallhead ('21; '35), Engr., 34 Knowle Lane, Ecclesall.
SOUTHERN, Herbert ('19; '23; '35), Dir., Charge Tech. Serv., G. P. Wincott, Ltd., 180 Attercliffe Rd.; *for mail,* 76 Knowle Lane, Ecclesall.

SLOUGH, Bucks

FRANCE, W. Henry ('34), Tech. Advisor to Pres., Black & Decker, Ltd., Slough; *for mail,* Dutch House, Datchet.

SMETHWICK, Stafford

FALLON, John (J'10), Managing Dir., Incandescent Heat Co., Ltd., Cornwall Rd., Smethwick, Stafford; *for mail,* Brynholme, St. Bernard's Rd., Olton, Warwick.

STAFFORD, Stafford

FIELD, Douglas A. ('32; '34; '35), Sr. Draftsman & Asst. Calculator, English Elec. Co., Ltd.; *for mail,* 159 Tixall Rd.

STAINES, Middlesex

TRESILLIAN, Stewart D. ('35; '35), Lagonda Motors.

STOCKPORT, Cheshire

DAY, Colin C. ('31; '35), Engr., Charge High-Speed Eng. Dept., Mirrless, Bickerton & Day, Ltd., Hazel Grove; *for mail,* 167 Buxton Rd.

TENTERDEN, Kent

HUDSON, Wm. S. ('28), Park Gate Farm.

WANTAGE, Berks

THURSTON, H. Geo. ('28), Managing Dir., Wantage Engrg. Co., Ltd.

WEALDSTONE, Middlesex

BENT, Walter G. ('20), Dir., Charge European Factories, Kodak, Ltd.

WELWYN GARDEN CITY, Herts

RYAN, Frank M. ('19; '25; '35), Asst. to European Mgr., Norton Co., Worcester, Mass; *for mail,* 10 High Oaks Rd., Welwyn Garden City, Herts, Eng.

WENTWORTH, Surrey

WILKINSON-ALLEN, Victor Reginald ('29), Sr. Engr., British Bedaux, Ltd., S. E. W. 102, Bush House, Aldwych, London, W. C. 2; *home address,* Tall Trees, Wentworth, Ditton Hill, Surrey.

WEYBRIDGE, Surrey

SPARKS, C. H. ('29), Ch. Engr., Babcock & Wilcox, Ltd., Babcock House, Farringdon St., London, E. C. 4; *for mail,* "Creebrae," High Pine Close, Weybridge, Surrey.

WOLVERHAMPTON, Stafford

THOMPSON, Stephen J. ('36), Governing Dir., John Thompson Water Tube Boilers, Ltd., Ettingshall.

WOODFORD, Essex

WATSON, H. D. ('35), Deputy Ch. Designer, Project Design Staff, Babcock & Wilcox, Ltd., Farringdon St., London; *for mail,* "Launcells," 39 Oakhill Crescent, Woodford Green, Essex.

FINLAND

ABO

HEIKEL, Daniel A. ('99), Life Member; M. E.

FRANCE

GRENOBLE, Isère

DANEL, P. (J'32), Lecturer, Hyd. Div., Grenoble Univ.; *for mail,* Hotel Majestic.

LILLE, Nord

NEU, Henri J. E. ('33), Pres., Société Anonyme des Etablissements Neu; *for mail,* 47 rue Fourier.

LYONS, Rhône

LEMAIRE, Pierre ('31), Dir., Ecole Centrale Lyonnaise, 16 rue Chevreul.

NOTRE-DAME-de-GRAVENCHON, Seine-Inférieure

CADEAU, Henry ('27), Mech. Supt. (M.E.), Stand. Franco Americaine de Raffinage.

PARIS

BERG, Hart O. ('98; '03), Cons. Engr., 26 rue Francois I.
BREGUET, Louis C. ('29), Dir. Gen., Founder, L. Breguet Aviation Wks.; *for mail,* 24 rue Georges-Bibet, Paris 16.
CANUEL, Jean A. (J'29), 6 rue du Marche, Le Vallois-Perret.
CLARK, Wallace ('19; '21), Cons. Engr., Wallace Clark & Co., 25 avenue Victor Emmanuel III.
DE FREMINVILLE, Chas. (H'19), 18 rue Pierre Curie, Paris 5.
DOWNE, Henry S. ('86), Chmn., European Managing Com., Am. Radiator Co., 40 W. 40th St., New York, N. Y.; *for mail,* 149 boulevard Haussmann.
FIEDLER, Alfred ('22), Dir. Gen., l'Auxiliaire des Chemins de Fer & de l'Industrie, 117 quai Jules-Guesde, Vitry-sur-Seine.
GARFIELD, A. S. ('07), 45 boulevard Beausejour.
HAHN, Henry P. ('26; '35), M. E., Charge Oil Refinery Sales, Société Anonyme des Etablissements Jules Cocard, 18 rue de Chatillon; *for mail,* 13 rue Ernest Cresson.
LEEWITZ, Geo. J. ('24; '30; '35), Gen. Mgr., Markt & Co. (Paris), Ltd., 107 avenue Parmentier.
LOUPPE, Albert ('28), Dir. Gen., Cie de Fives-Lille, 7 rue Montalivet, Paris 8.
MAGIS, Auguste A. G. ('23), Administrator, Cie des Surchauffeurs, 29 rue de Berri, Paris 8.
PETITJEAN, Chas. P. ('20), Ch. Engr., Ingersoll-Rand Co., 46 rue de Courcelles; *for mail,* 107 rue de Rome, Paris 17.
SCHMID, W. E. ('36), Cons. Engr., 54 Blvd. Péreire, Paris 17.
SHEPARD, Simeon ('04; '13), Cons. Engr., Bldg., Constr., 45 avenue de Friedland, Paris 8.
SMITH, Marshall M. ('29; '35), Dir., Société Worthington-Batignolles, 45 avenue Kleber.
SUPLEE, Henry Harrison ('88), Manager, '97-'00; 9-bis rue des Ecoles, Creteil, Seine.
TAFFANEL, Jacques ('21), Dir. Gen. Adjoint, Cie. des Forges de Chatillon, Commentry & Neuves-Maisons, 19 rue de la Rochefoucauld.
WARREN, Francis W. ('20), Pres., F. W. Warren & Co., 52 Champs Elysées.

TASSIN, Rhône

MORAT, Jacques ('09), Mgr., Fdy. Dept., M. Berliet, Venissieux; *for mail,* 3 Allée Ronsard.

VILLEFRANCHE-SUR-MER, Alpes-Maritimes

GARNIER, Alphonse ('29), Life-Member; Member, Bd. Directors, Cie. de Fives-Lille, 7 rue Montalivet, Paris; *for mail,* Villa "Dianina," Villefranche-sur-Mer.

GERMANY

AACHEN

LANGER, Paul ('24), Prof. M. E., Technische Hochschule.

AIX LA CHAPPELLE

WALLICHS, Adolf ('08), Prof. M. E., Tech. Univ. of Aix la Chapelle, Nizza Allee 65.

BERLIN

FITZGERALD, John W. (J'28), John McMullen Research Scholar, Sibley College, Cornell Univ., Ithaca, N. Y.; *for mail,* Dresdner Bank, Berlin, Germany.
HERPEN, A. Theo. ('25), Managing Dir., Steam Boilers & Power Plants, Gesellschaft für La Mont Kessel und Kraftwirkschaft, m. b. h., Schadowstr. 1 b, N. W. 7.
HEYERDAHL, Thorvald ('12), Export Mgr., S. A. Ferrum, Katowice, Poland; *for mail,* Neue Grünstr. 18, Berlin, S. W. 19, Germany.
MATSCHOSS, Conrad ('13), Life Member for Distinguished Service, '13; Prof., Mem. of Council Verein deutscher Ingenieure, 27 Hermann Goering Str.
MUNZINGER, Friedrich ('25), Dir. Allgemeine Elektricitäts-Gesellschaft, Friedrich-Karl-Ufer 2/4, N. W. 40.
NEUHAUS, Fritz ('98; '06), 33 Pariserstr., W. 15.
QUEISSER, H. W. ('28; '34; '35), M. E., Siemens-Schuckertwerke A. G.; *for mail,* Jungfernheideweg 10, Berlin-Siemensstadt.
SCHULZ, E. ('26; '35), Duesseldorferstr. 19/20. W. 15.
STUMPF, Johann ('96), Privy & Govt. Counselor, Kurfurstendamm 33, W. 15.
TATARSKY, Geo. F. (J'31), M. E., Allgemeine Elektricitäts-Gesellschaft, Friedrich-Karl-Ufer 2/4, N. W. 40.
ZUR NEDDEN, Franz ('29), Secy., Charge Tech. Committee, Reichskohlenrat, Pariser Str. 44, W. 15; *for mail,* 28, Prager Str., W. 50.

BLANKENESE-ELBE

DUENSING, Heinrich F. A. ('26; '35), Teacher of Matls. Handling, Technology, Höhere Technische, Staatslehranstalten, Hamburg, Luebecker Tor, Hamburg; *for mail,* Zur Fernsicht 15, Blankenese-Elbe.

BREMEN

BLAUM, Rudolf ('30), Dir., Atlas-Werke, A. G., Stephanikirchenweide.

CHARLOTTENBURG

FROELICH, Friedrich Carl ('13), Cons. Engr., Adolf Hitler-Platz 8, Charlottenburg 9.

DARMSTADT

VOIGT, Heinz ('26), Prof., Technische Hochschule; *for mail,* Hobrechtstr. 28.

DRESDEN

HANKE, Walter (J'33), An den Kalkoefen 17, Dresden-Reich.

HAMBURG

PETERS, Claudius ('30), Pres., Claudius Peters, Glockengiesserwall 2, Hamburg 1.
SCHUETZ, Werner V. ('27), Sophienstr. 24, Hamburg 4
VON SCHOENAICH, Stephan F. ('28; '35), Sales Engr., Deutsch-Amerikanische Petroleum Gesellschaft, 21 Neuer Jungfernstieg, Hamburg 36; *for mail,* 65A, Magdalenenstr., Hamburg 13.

HEIDENHEIM

LANG, Richard T. ('25), Tech. Dir., J. M. Voith Maschinenfabrik, Heidenheim/Brenz.

KARLSRUHE

STREETER, Victor L. (J'35), Kornbloomstr. 1.

LEIPZIG

BRANDT, Franz ('29), Helfferichstr. 50, Leipzig C 1.

MAGDEBURG

KLEIN, Otto Karl ('27), Gen. Mgr., Schaeffer & Budenberg.

MANNHEIM

KÖLSCH, Otto ('25), Tech. Dir., Heinrich Lanz, Aktiengesellschaft, Lindenhofstr.

MUNICH

HEALY, Geo. W. (J'33), Tuerkenstr. 58.
MAYR, Karl A. ('27; '35), Pat. Atty., 90 West St., New York, N. Y.; *for mail,* Maximilianstr. 20b, Munich, Germany.
THOMA, Dieter ('25), Prof., Technische Hochschule; *for mail,* Nordliche Auffahrtsallee 23, Munich 19.

NEUSS

SCHAURTE, Werner T. ('27), Pres., Bauer & Schaurte.

ROTTACH-EGERN

FALIAN, Curt L. ('31), Landhaus Nr. 81, Rottach-Egern, Oberbayr.

SCHWELM

GRIESENBECK, Wm. (J'27), Wks. Mgr., G. Griesenbeck, Bahnhofstr. 41, Schwelm, Westfalen.

STUTTGART

NESTEL, Hermann A. (J'27), c/o Betriebstech-Landesgewerbemuseum, nische Ausstellungen.
SCHUETZE, Gerhard (J'30), c/o Robert Bosch A. G., ZW/WZE.

GREAT BRITAIN

England. See Page 164

Ireland. See Below

Scotland. See Page 166

GREECE

ATHENS

FLORAS, Christos L. (J'28), Prof. & Dir., Charge Sanitary Engrg. Sch. of Hygiene, Ministry of Hygiene; *for mail,* 9 Lefkossias St.

HOLLAND

See (The) Netherlands, Page 166

IRELAND

BELFAST

ALEXANDER, David H. ('28; '34), Prin., College of Tech.; *for mail,* 606 Antrim Rd.

ITALY

BRESCIA

MARZOLI, Luigi (J'08), Gen. Mgr., Supt., Fratelli Marzoli, Palazzolo s/Oglio.

FINALE LIGURE

CASIRAGHI, Giovanni P. ('28; '34; '35), Ch. Engr., Tech. Dir., Piaggio & Cie.

FLORENCE

FOSTER, Ernest H. ('85; '94), Villa la Colombaia, Via Marignolle 2.

IVREA

OLIVETTI, Adriano (J'26), V. P., Gen. Mgr., Ing. C. Olivetti & C. S. A.

MILAN

CATTANEO, Giustino ('30), Ch. Designer for Aero. Eng. & Lorries, S. A. Alfa Romeo, via M. U. Traiano 33; *for mail*, 32 Via Leopardi.
REGGIORI, Alessandro (J'35), Research Engr., Societa Italiano Ernesto Breda.

RIVOTELLA DEL GARDA

ANDREI, Camillo ('11; '26).

ROME

PERRONE, Pio (H'20), Grande Ufficiale Ing., Via Pinciana Nuova 36.

TERNI

ALBERTI, Alforisio ('35), Gen. Dir., Steel Plants, "Terni" Societa per l'Industria e l'Elettricita, Viale Brin.

LITHUANIA

KAUNAS

GRAICUNAS, V. A. ('24; '33), Mgmt. Consultant, Ordnance Dept. & Military Aviation; *for mail*, Vaižganto g-vė 12 but. 7.

(THE) NETHERLANDS

AMSTERDAM

BLICKMAN, John A. ('14), Mem. Firm, Koopman & Co., Stadhouderskade 6.
CHORASO, Z. (J'32), Engr., Charge Stress Analysis, N. V. Nederlandiche Vliegtuigenfabrich Fokker, Amsterdam Naviel; *for mail*, c/o Dr. E. Schatzki, Minervalaan 82hs, Amsterdam, Zuid.
REYDON, Henry (J'30), c/o Dr. J. Smit, 12 Minerva Laan.
VERKOZEN, A. J. (J'31), Cons. Mgmt. Engr., Joh. Verhulstraat 91.

HAARLEM

JULIUS, M. A. ('31), Ch. M. E., Joh. Enschedé en Zonen, Graf. Inrichting N. V., Klokhuisplein 5.

HENGELO

EHRENBURG, Hillebrand Hendrik ('28), Dir., Twentsch Centraal Station, 103 Enschedeschestraat, Hengelo, Overijsel.

SCHEVENINGEN

HOFFMANN, Simon ('11), 80 Nieuwe Parklaan.

THE HAGUE

VAN DONGEN, J. R. Johan (J'35), N. V. Bataafsche Petroleum Maatschappij, Carel van Bylandtlaan 30.

UTRECHT

DRESDEN, D. ('28), Pres., Jaffa Eng. Wks., Groeneweg; *for mail*, Burg., Reigerstr. 89.

NORWAY

KRISTIANSAND

GARSON, Henrik N. ('24), Kristiansand, S.

OSLO

BALCHEN, Bernt ('30; '35), Charge Tech. Div., Det. Norske Luftfartselskap, Toldbod. gt. 1b; *for mail*, Voksenlia.
FIRING, Wilh. ('28), Heat Engrg., Thunes Mek. Verk, P. B. 225.
KAHRS, Otto ('19), Supvr. State Bldgs., Norwegian Civil Serv., Ullevoldsveien 72; *for mail*, Thomas Heftyesgate 62.
KLARFELT, Kristian ('29), Magnus Barfots gt. No. 9.
SVENDSEN, Halfdan ('26; '35), Designing Engr., Wisbech A/S; *for mail*, Gabels gt. 48.

SKOTBU

LOBBEN, Peder ('95).

POLAND

LWÓW

AULICH, Witold M. ('23; '35), Prof. M. E., Polytechnic of Lwów, Leona, Leona Sapiehy 12; *for mail*, Dunin-Borkowskich 2.

WARSAW

ZOWSKI-ZWIERZCHOWSKI, S. J. ('10), Filtrowa 13.

ROMANIA

BUCHAREST

ORGHIDAN, Constantin ('27), Pres., Metallurgical & Mining Industries Assn. of Romania, Str. Pitar Mosu No. 3, Bucharest I; *for mail*, 9 Str. Alex. Lahovary, Bucharest III.
ROMAN, Harvey ('18; '18; '30), Str. Nec. Filipescu, 25, Bucharest I.

RUSSIA

See Union of Socialist Soviet Republics, Next Column

SCOTLAND

ALLOA, Clackmannon

MACNEE, Chas. M. ('26), Ch. Engr., Patons & Baldwins, Ltd.; *for mail*, 27 Church St.

BEARSDEN, Dunbarton

RAWORTH, Albert S. ('29), M. E. Charge Maint., Singer Mfg. Co., Ltd., Clydebank; *for mail*, Eblana, Thorn Dr., Bearsden, Dunbarton.

BRIDGE OF WEIR, Renfrew

MELLANBY, Alex. L. ('26), Westwood.

EDINBURGH

DOUGLAS, John ('30), Redlac, Colinton.
PARTRIDGE, Harry E. ('25), 79 Craiglockhart Rd.

GLASGOW, Lanark

DAVIES, Albert W. ('30), Dir. & Wks. Mgr., Mavor & Coulson, Ltd., 47 Redan St., S. E.
FLEMING, J. Taylor (J'28), Ch. Engr., Wks. Mgr., Jas. Howden & Co., Ltd., 195 Scotland St., C. 5.
GOUDIE, Wm. J. ('31), Prof. Theory & Practice of Heat Engrg., Univ. of Glasgow, Glasgow; *for mail*, Bellevue, 1 Kay Park Terrace, Kilmarnock.
SEMPLE, D. M. ('19; '28), Managing Dir., Mirrlees Watson Co., Ltd., 45 Scotland St.
WEIR, The Rt. Hon. Lord (H'20), Chmn. of Dirs., G. & J. Weir, Ltd., Holm Fdy., Cathcart.
YARROW, Sir Harold E. ('19), Managing Dir., Messrs. Yarrow & Co., Scotstown.

JOHNSTONE, Lanark

LANG, John B. ('16; '26), Dir., John Lang & Sons, Johnstone nr. Glasgow; *for mail*, Rossall, Kilmacolm, Renfrew.

KILMARNOCK, Ayr

LIVINGSTON, Alex C. (J'35), Asst. Engr., Charge Design, Messrs. Glenfield & Kennedy, Ltd., Low Glencairn St., Kilmarnock; *for mail*, 6 Jeffrey St., Riccarton.

NEWPORT, Fife

KNOX, Jas. R. ('31; '35), Cons. Engr., 9 Union St., Newport, Fife; *for mail*, 26 Commercial St., Dundee.

PAISLEY, Renfrew

HODGART, Hugh M. ('35), Dir., Fullerton Hodgart & Barclay, Ltd.; *for mail*, Westerly, Meikleriggs.
WHITE, Thos. ('30), Managing Dir., Thos. White & Sons, Ltd.; *for mail*, Hillside.

SPAIN

BARCELONA

BECH, Jose ('28; '31; '35), Pasaje Sagrista 9.
HOBBLE, Arthur C. ('14), Ch. Engr., Ebro Irrigation & Power Co.; *for mail*, Apartado 491.
MILLS, Chas. P. ('31; '35), Power Engr., Riegos y Fuerza del Ebro S. A., Apartado 491, Plaza Caraluna 2.
POMEROL, Laurent ('29), Asst. Tech. Mgr., Riegos y Fuerza del Ebro, Calle Gerona 1.

MADRID

GREEN, Lorn A. ('24; '28; '35), Spec. Rep., Ingersoll-Rand S. A., Apartado 518, Montalban 5.
MONTANES, Charles E. ('20), Gen. Inspc. of Govt. Bd. of Industry, Goya 8; *for mail*, Goya 83.

SWEDEN

BORAS

ENGBLOM, Alex ('14; '35), Wks. Mgr., Boras Wafveri Aktiebolag; *for mail*, Varbergsvagen 25.

FINSPONG

NORDIN, John A. ('21), Wks. Mgr., Svenska Turbinfabriks Aktiebolaget Ljungström.
WIBERG, Oscar ('31), Ch. Engr., Svenska Turbinfabriks Aktiebolaget Ljungström.

LANDSKRONA

LILLIESWAN, Sten ('31; '35), Engr., Charge Design, Landsverk; *for mail*, 18 Järnvägsgatan.

NORRKOPING

FLATER, Harold ('22), Wks. Mgr., Internatl. Harvester Co.

STOCKHOLM

CARLSON, Axel F. ('32), Gen. Mgr., Aktiebolaget A. C. Gustafson, Sodra Kungstornet.
KAERNEKULL, Carl Olof ('21; '35), Chief, Dept. Indus. Organization, Federation of Swedish Industries; *for mail*, Grevturegatan 38.
LINDKVIST, Gustav A. ('31), Aktiebolaget Nordstroms Linbanor, Vasagatan 16.
LINDHAGEN, Manne T. ('33), Managing Dir., Aktiebolaget Ljungströms Ångturbin, Kungsgatan 32; *for mail*, Rådmansgatan 22.
WEIBULL, Prof. Waloddi ('35), Univ. of Tech.; *for mail*, Saltsjobaden.
WETTSTEIN, F. A. ('26; '35), M. E., Charge Research, A. B. Spontan; *for mail*, Vartavagen 13v.

VASTERAS

HANSSON, Axel S. ('32), Ch. Engr., Charge Mech. Design, ASEA, Västerås, Sweden.

SWITZERLAND

BERNE

KRAUT, Chas. R. ('26; '35), Major, Kriegstechnische Abteilung; *for mail*, 3 Hirschengraben.
ZUBERBUEHLER, Paul (J'30), Designer, L. de Roll Ironworks, Berne Fdy.; *for mail*, 8 Gesellschaftsstr.

ST. GALLEN

LAEMLE, Milton M. ('25; '33), Owner, Laemle & Co., Unterstr. 15; *for mail*, Tannenstr. 14.

VEVEY

LOCKWOOD, Frank A. ('21), 2 Ave. des Pleiades.

WINTERTHUR

KJELSBERG, H. A. ('23), M. E., Swiss Loco. & Mch. Wks.; *for mail*, 42 Pflanzschul Str.
OEDERLIN, Fred'k ('16), Managing Dir., Charge Engrg., Sulzer Bros. Ltd.

ZURICH

KELLER, Hermann R. ('22; '35), Tech. Agencies, 103 Freistr., Zurich 7.
SIDLER, Edw. H. ('26), Supt., Technischer Arbeitsdienst Zurich, Schulhausstr. 62; *for mail*, F, Viktroria Str., Zurich 11.

TURKEY

ISTANBUL (Constantinople)

AVRAM, M. H. ('33), Cons. Engr., Hayirli Apts., Pera.
SCIPIO, L. A. ('12), Dean of Engrg., Robt. College.

UNION OF SOVIET SOCIALIST REPUBLICS

GORKI, Nizhni Novgorod

ZUCKERMAN, Nathan E. (J'31), Mgr., Mch. Shop, Automobile Plant "Molotoff," (Avtozavod).

KHARKOV

HENCKY, H. ('32), Prof. Applied Mechanics, Kharkov Chemico-Technological Inst.; *for mail*, Frunze.

TRASHUTIN, I. Y. (J'33), Engr., Charge Design, Diesel Dept., Kharkov Loco. Wks., 126 Plechanov St., Kharkov 6; *for mail,* 3 Meatallistow St., Kharkov 51.

LENINGRAD

KOUSMIN, Serge ('35), Kirowsky prosp. 1/3, kw. 37, Leningrad 46.
KROTOFF, E. G. ('30), Prof., Wood Tech. Academie; *for mail,* Apt. 27, Matvejevskaja Str. 11, Leningrad Petrogradskaja Stor.

PLINER, Isiah D. ('28; '35), Sub-Prof., Kuibyshew Inst. of Automotive & Highways Engrg.; Research Engr., Cent. Inst. for Marine Transportation; *for mail,* Prosp. 25th October, 23.

MOSCOW

AISENSTEIN, Michael D. ('26; '33), *Junior Award,* '28; Ch. Engr. & Cons. Engr. for Glavormash. Kalinin Pump & Turbine Plant, Bolshaya Tatarskaya 13; *for mail,* Apt. 24, Donskaya 42.
FAYMONVILLE, Maj. Philip R. ('18; '25; '35), Military Attaché, U. S. A., Am. Embassy.
GRAMP, Alex. N. (J'32), Dean of Graduate Sch., Moscow Electro-Mech. Inst. of Transport; *for mail,* Apt. 26, Bachmetevsky 15.
UGER, D. A. ('32), Apt. 2, Smolenski Bulvar 10.

NAVOSIBERSK, Siberia

COTHER, A. A. ('36), Head of Div., Project Dept., Kuzbasshaftstroy.

OCEANIA

AUSTRALIA

ADELAIDE, South Australia

GREEN, Wm. ('27; '35), Head Master, Ironworkers Trade Sch., Education Dept. of S. Australia; *for mail,* 12 Shipster St., Torrensville.
KINCAID, Russell M. ('20), Gen. Motors-Holden's, Ltd.

AUBURN, New South Wales

ROOSTE, Ernest E. ('26; '35), Head, Inspc. & Testing Dept., Australian Gen. Elec. Co., Ltd., Percy St.

BRISBANE, Queensland

AXON, Albert E. ('28; '35), Cons. Engr., Bank of Australasia Chambers, Queen St.
EVANS, Daniel Edw. ('33), Chmn. Bd. Dirs., Evans, Deakin & Co., Ltd., Ryan House, Charlotte St.

CASTLEMAINE, Victoria

BURNELL, John G. ('24), Tech. Dir., Thompsons Engrg. & Pipe Co., Ltd.; *for mail,* Parker St.
HENRY, Jos. S. ('11), Cons. Engr., Austral Malay Tin Dredging, Ltd.; *for mail,* Barrington, Hargreaves St.
MORTON, Arthur B. ('17), Thompsons Engrg. & Pipe Co., Ltd.

ELWOOD, Victoria

MEALAND, Alfred ('29), Ch. Draftsman, Munitions Supply Bd., Dept. of Defence, St. Kilda Rd., Melbourne; *for mail,* 36 Cole St., Elwood.

FOOTSCRAY, Victoria

SAENGER, Geo. W. ('19; '35), Managing Dir., Maize Products Pty., Ltd.

LITHGOW, New South Wales

FORD, Arthur Saml. ('18; '35), Mgr., Commonwealth Small Arms Factory.

MARIBYRONG, Victoria

STANLEY, Robt. ('27; '35), Engr., Prod. Ordnance Factory, Commonwealth of Australia.

MELBOURNE, Victoria

JOHNSON, Claude Cecil ('28), Wks. Mgr., Dir., Johnson Sons Pty., Ltd., Tyne Foundry.
LANYON, Lewis H. (J'35), 37 Harrow St., Box Hill E 11.
LUIGGI, Mario L. ('21; '35), Pur. Agt., Gen. Motors-Holden's, Ltd., Fishermen's Bend.
RIGBY, Edward J. ('18), Tech. Dir., Robert Bryce & Co. Proprietary, Ltd., Bryce Bldg., 526-32 Little Bourke St.
SMITH, Vernon ('28), Managing Dir., John Thompson (Aust.) Pty., Ltd., 312 Flinders St.

MIDLAND JUNCTION, Western Australia

MILLS, Frederic ('28; '35), Ch. Draftsman, West. Australian Govt. Rys.
PROCTER, Stanley Wm. (J'29), Testing Officer, West. Australian Govt. Rys., Ch. M. E. Office, Midland Junction; *for mail,* 27 North St., Mt. Lawley.

OSBORNE, South Australia

CHAPMAN, Arthur H. (J'30), Sr. Asst. Engr., Adelaide Elec. Supply Co., Ltd.

SYDNEY, New South Wales

HART, Lawrence H. ('29; '35), Asst. Engr., New South Wales Dept. of Rys., Ry. House, 19 York St.
PALMER, W. J. D. (J'28), Asst. Physical Testing Officer, Australian Gas Light Co., 35-43 Australia St., Camperdown.
PRICE, Norman I. ('02; '21), Price, Martyn & Co.; *for mail,* Box 255, G. P. O.
RATCLIFFE, Fred'k R. ('22), Cons. Engr., 36 Woodside Ave., Strathfield.
SHIRTLEY, S. L. (J'35), Combustion Engr., Babcock & Wilcox, Ltd., Regents Park.
WARNER, Leslie T. ('36), Elec. Engr., Sydney Co. Council, Queen Victoria Bldg., Sydney; *for mail,* 5 Keppel Ave., Concord.

(TERRITORY OF) HAWAII

See Page 53

JAVA

(Netherlands East Indies)

BATAVIA

ORR, Claude H. ('19; '26), Box 81.

SUMATRA

(Netherlands East Indies)

SOENGEI GERONG, Palembang

MILLER, Ernest Geo. (J'31), N. K. P. M., Hulposkantoor Soengei Gerong, Nabij Palembang.
WAGNER, Jerold G. (J'36), N. K. P. M., Soengei Gerong.

NEW ZEALAND

AUCKLAND

HEPTINSTALL, W. G. ('23; '35), Plant Mgr., Waikato Carbonisation, Ltd., Ferry Bldgs., Auckland; *for mail,* Rotowaro P. O., Huntly.

CHRISTCHURCH

STEELE, S. ('28), Prof. M. E., Canterbury College.

PHILIPPINE ISLANDS

See Page 146

* * * * *

PRESENT ADDRESS UNKNOWN

ATKINSON, William ('33).
de AROZARENA, Rafael M. ('85), Life Member.
FONTENAY, Lawrence Lyon (A'31).
GREENE, Isaac C. ('82; '86), Life Member.
GUELBAUM, David ('94; '05).
RAIF, A. S. (J'31).

SUMMARY OF GEOGRAPHICAL LIST

UNITED STATES

Including Territories and Dependencies

Alabama	72
Alaska	1
Arizona	11
Arkansas	17
California	753
Canal Zone	8
Colorado	87
Connecticut	492
Delaware	76
District of Columbia	185
Florida	81
Georgia	97
Hawaii	30
Idaho	12
Illinois	878
Indiana	209
Iowa	65
Kansas	63
Kentucky	62
Louisiana	109
Maine	38
Maryland	168
Massachusetts	795
Michigan	494
Minnesota	100
Mississippi	19
Missouri	245
Montana	27
Nebraska	30
Nevada	10
New Hampshire	38
New Jersey	1127
New Mexico	8
New York	3564
North Carolina	94
North Dakota	6
Ohio	889
Oklahoma	98
Oregon	59
Pennsylvania	1523
Philippine Islands	16
Puerto Rico	22
Rhode Island	148
South Carolina	24
South Dakota	8
Tennessee	117
Texas	239
Utah	37
Vermont	27
Virginia	135
Washington	124
West Virginia	76
Wisconsin	263
Wyoming	8
Total	13884

OTHER COUNTRIES

North America		
Canada	218	
Mexico	27	
Newfoundland	3	
		248
Central America		
Costa Rica	3	
Panama	2	
		5
West Indies		
Aruba	5	
Bermuda	1	
Cuba	33	
Dominican Republic	4	
Jamaica	1	
Trinidad	1	
		45
South America		
Argentina	17	
Brazil	14	
Chile	11	
Colombia	13	
Peru	2	
South America (*continued*)		
Uruguay	1	
Venezuela	8	
		66
Africa		
Egypt	1	
Morocco	1	
Union of South Africa	10	
		12
Asia		
China	20	
India	53	
Japan	16	
Malay Peninsula	3	
Palestine	1	
Siam	1	
Syria	1	
		95
Europe		
Austria	1	
Belgium	4	
Czechoslovakia	7	
Denmark	7	
England	92	
Finland	1	
Europe (*continued*)		
France	25	
Germany	34	
Greece	1	
Ireland	1	
Italy	9	
Lithuania	1	
Netherlands	9	
Norway	7	
Poland	1	
Romania	2	
Scotland	16	
Spain	6	
Sweden	12	
Switzerland	8	
Turkey	2	
Union of Socialist Soviet Republics	11	
		257
Oceania		
Australia	26	
Java	1	
New Zealand	2	
Sumatra	2	
		31
Total		759

United States, Territories and Dependencies	13884
Other Countries	759
Present Address Unknown	6
Total	14649

STUDENT MEMBERS

THE following roster of names of Student Members of The American Society of Mechanical Engineers, grouped under the Student Branches to which they belong, was the complete list on file at the Society headquarters on January 1, 1937.

University of Akron

- Alexander, A.
- Brubaker, F. A.
- Buchtel, K. A.
- Cornell, D. H.
- Fretz, G. C., Jr.
- Fuller, C.
- Good, J. F.
- Groney, C. W.
- Harper, T. C.
- Harris, J.
- Kolk, C.
- Kovach, J. I.
- Levin, S. L.
- Martin, J. E.
- Orr, G. H.
- Roppel, J. G.
- Rottmayer, E.
- Saus, F. J.
- Taylor, E. R.
- Vukan, F. S.
- Weaver, T. C.

Alabama Polytechnic Institute

- Bagby, F. K.
- Bodden, T. R.
- Briggs, E. W.
- Burrus, G. J., III
- Collins, G. J., Jr.
- Crumbaker, M. O.
- Dodge, R. T.
- Frey, F. G., Jr.
- Hair, R. M., Jr.
- Kemp, M. G.
- Maples, G. R., Jr.
- Mardirosian, M.
- McDonald, J. M.
- Memory, S. T., Jr.
- Morgan, J. I.
- Pollard, E. E.
- Pollard, H. B., Jr.
- Richter, F. H.
- Vaughan, W. W.
- Ward, G. F.
- Whitting, H. C.

University of Alabama

- Adamson, J. R.
- Downs, H. R.
- Drake, D. L.
- Felheimer, C.
- George, E. T., Jr.
- Herman, W. R.
- Johnson, L. S.
- Klimas, C. P.
- Krotee, W. R.
- LeCompte, F. M.
- LeMay, C. F.
- Riordan, W. J.
- Schneller, R. J.
- Sheaff, P. P.
- Thaler, H. A.
- Vettel, E. E.
- Worstmann, J. M., Jr.
- Zampieri, U.

University of Arkansas

- Adams, J. B.
- Beckman, W. F.
- Brown, J. M.
- Keating, T. J.
- Lewis, W. A., Jr.
- Pratt, W. E.
- Slayden, J. W.
- Stelzner, W. B., Jr.
- Stevenson, R. F.
- Whitaker, A. W.

Armour Institute of Technology

- Appel, H. L.
- Aravosis, N. S.
- Badalich, F. C.
- Bartusek, J. F.
- Bolz, W. J.
- Bystricky, J. C.
- Carlson, W.
- Carroll, K. F.
- Chelgren, W. J.
- Chen, W.-S.
- Close, R. G., II
- Collins, W. E.
- Crapple, J.
- Damiani, J. H.
- DeBoo, J. L.
- Dodge, R. A.
- Droegemueller, E. A.
- Feder, A.
- Fleissner, A. G.
- Franzen, P.
- Gryglas, S.
- Hanneman, F.
- Hazleton, W. J.
- Hlousek, J.
- Hockert, C. E.
- Horwich, D.
- Immekus, R. C.
- Janas, L. J.
- Jandasek, V. J.
- Jones, H. McP.
- Kinder, R.
- Kovacik, O. J.
- Loftus, M. J.
- Logullo, L.
- Malmfeldt, C. S.
- Mandelowitz, A.
- Maxant, R. E.
- Menke, E. W.
- Meyer, H. L.
- Meyer, H. M.
- Miner, S. M.
- Modes, E. E.
- Nauman, C. K.
- Nearing, W. C.
- Neuert, P.
- Nicholas, H. B.
- Niemann, R. F.
- Oswald, B. F., Jr.
- Peterson, R. G.
- Plummer, E., Jr.
- Prochaska, J. J.
- Reh, P. A.
- Roche, W. J.
- Rueff, R. A.
- Ruekberg, H. S.
- Rune, A.
- Saltzman, I. K.
- Sauermann, W. O.
- Schreiber, A. N.
- Shanahan, J. E., Jr
- Skach, F. J.
- Staradub, E. P.
- Skrzydlewski, E. G.
- Sypniewski, E.
- Tegtmeier, W. G.
- Thomas, I.
- Waldron, T.
- Winblad, R. A.
- Winel, P.

Brooklyn Polytechnic Institute

- Albrecht, R. J.
- Bennett, J. V.
- Cannizzaro, S.
- Cordiano, J. J.
- Dudzinski, S.
- Effinger, W.
- Eriksen, W. R.
- Grantz, H. E.
- Grasmann, B. J.
- Hallum, T. E.
- Hayes, E. G.
- Heim, W.
- Heller, P. R.
- Katzen, S.
- Keck, F. C.
- Lawson, E. C., Jr.
- London, H.
- Manilych, S.
- Mayorga, D.
- Maystrik, G. G.
- McFarland, G.
- McGowan, T. J.
- McKenna, C. N.
- McLoughlin, F. E.
- Morrow, J. G.
- Niarakis, V.
- Novara, J.
- Olson, W. H. M.
- Pitman, D.
- Rubinsky, S.
- Sausele, G.
- Savitsky, P.
- Shwert, W.
- Stirba, A., Jr.
- Umanoff, M.
- Vanella, J. T.
- Walton, R. E.
- Wepfer, W. M.
- Zemetra, M. J.

Brooklyn Polytechnic Institute

Evening Division

- Baldwin, F. M.
- Bolsetzian, E.
- Dingelstedt, C.
- Erickson, E. A.
- Faast, F. E.
- Glazar, C.
- Griner, A. J.
- Haughwout, J. A.
- Isbister, J. C.
- Kertesz, C.
- McDuffee, J. K.
- Mogerley, A.
- Monnier, R.
- Overbagh, H. M.
- Rothman, N.
- Sidrane, H.
- Stad, A. N.
- Wimmer, C.
- Wunderlin, G. J.

Brown University

- Allen, F. T.
- Anderson, R. E.
- Bancroft, E. K.
- Banta, J. J.
- Barber, E. A., Jr.
- Batty, D. E.
- Darling, A. B.
- Dow, G. S., Jr.
- Gilbert, N. R.
- Gilbreth, F. M.
- Harrington, H. A.
- Lathrop, J. E., Jr.
- Lippman, H. F.
- Nicholson, H. S.
- Pickering, E. F.
- Prudden, N. P.
- Sawyer, F. A.
- Tingley, J. W., Jr.

Bucknell University

- DeMuro, S. A.
- Distel, W. I., Jr.
- Geiss, J.
- Gundrum, H.
- Kob, L. B.
- McDowell, L.
- McLain, R. D.
- Muir, J. E.
- Petherbridge, J. H.
- Schreiber, C. F.
- Taylor, R. S.
- Zimmerman, W. D.

California Institute of Technology

- Althouse, W. S., Jr.
- Ambroff, M.
- Ashkenas, I. L.
- Barry, R. J.
- Benton, R., Jr.
- Bonham, E. H.
- Budenholzer, R. A.
- Bussard, G. L.
- Carr, R. E.
- Clarke, C. W.
- Cornwall, E. W.
- Dike, M. A.
- Dion, F. E.
- Downing, C. A.
- Ellis, H. B.
- Feuer, S.
- Fleming, L.
- Forward, R. B.
- Friend, C. F.
- Grainger, B. B.
- Hotz, G. M.
- Johnson, E. A.
- Jones, R. W., Jr.
- Kelly, B. H.
- Kinley, J. C.
- Lawson, W. G.
- Lycett, E. A.
- Moncrief, E.
- Nojima, N.
- Peterson, J. J.
- Poggi, M. J.
- Porter, E. J.
- Segelhorst, A.
- Sullwold, J.
- Townsend, R. D., Jr.
- Tsao, C.-C.
- Tsubota, G. Y.
- Van der Werff, J.
- Velazquez, J. L.
- Voorhees, S. V.
- Warner, H. F.
- Wetmore, W. O.
- Wheeler, W.
- Wilkinson, L. A., Jr.
- Wolfberg, S. T.
- Wood, H. J.
- Wylie, W. G.

University of California

- Agern, A. T.
- Albrecht, D. K.
- Ball, R. E.
- Ball, W. B., Jr.
- Bardoff, L. F.
- Barker, W. E.
- Bentson, H. G.
- Bertola, P. H.
- Binhham, K. B.
- Brazil, R. M.
- Brown, S. C.
- Brye, J. M.
- Burrier, H. E.
- Carlson, B. M.
- Cherry, L. H.
- Childs, G. D.
- Collins, A.
- Corcoran, D. E.
- Corey, K. L.
- Cornwell, W. A.
- Coulter, J. B.
- Crouch, J. M.
- Daspit, L. R.
- Dawson, J. T.
- Del Mar, B. E.
- Deluchi, F.
- Dewar, W. R.
- Dickson, R. L.
- Diemas, J. L.
- Donohue, T. F.
- Dooley, J. L.
- Dorward, J. G., Jr.
- Eastin, B. P.
- Eckberg, H. F.
- Estrada, C. A.
- Fitzgerald, F. H.
- Garbett, C. R.
- Gessling, G. F.
- Gillice, F. A.
- Goon, B.
- Gordon, H. S.
- Gratz, D.
- Green, J. E., Jr.
- Greiner, M. C.
- Heeren, D. W.
- Henderson, R. W.
- Herdman, W. J.
- Hirt, J. H.
- Hutchinson, F. W.
- Iversen, H. W.
- Jelinek, J.
- Johannes, P. E.
- Johnson, H. G.
- Jordan, J. A.
- Kane, E. D.
- Kanemitsu, S.
- Karnaugh, N. I.
- Karstens, N. V.
- Kaufman, W. R.
- Kellogg, F. D.
- Kindblad, K. T.
- Kline, L. W.
- Kosman, M.
- Laitone, E. V.
- Levinson, H. R.
- Levy, J.
- Liedstrand, E. H.
- Lindberg, J. E., Jr.
- Lunde, J. P.
- MacIntyre, N. R.
- Maledy, J. E.
- Martin, R. W.
- Matting, F. W.
- McCollum, F. H.
- Meyer, J. L.
- Meyers, R. Y.
- Miller, J. A.
- Mohler, L. J.
- Mouser, W. F.
- Mullen, L. H.
- Munger, M. P., Jr.
- Napier, E. T.
- Nevius, S. G.
- Newman, J. P.
- Noguchi, D.
- Nutting, W. H.
- O'Brien, J. T., Jr.
- O'Neill, R. R.
- Orvis, W. C.
- Palmer, J.
- Papas, J. C.
- Parker, A. F.
- Petroff, G.
- Polland, S.
- Porter, F. H.
- Powers, R. D.
- Poyser, S.
- Prout, E. R.
- Puck, R. F.
- Ranney, R. P.
- Ricker, R.
- Sachs, H.
- Sanborn, D. S.
- Scheeline, L. A., Jr.
- Schinnerer, R. L.
- Schweitzer, F. J.
- Shank, J. L.
- Shelden, R. F.
- Smith, W.
- Stanly, A. L.
- Stoddard, J. L.
- Styerwalt, A. J.
- Sulliger, A. H.
- Thayer, P. A.
- Tom, H. D.
- Tramontini, V. N.
- Voorheis, T. S.
- Walden, W. R.
- Walker, A. R.
- Wasserman, M. E.
- Watson, F. R.
- Weinberg, E. B.
- Withington, C. A., Jr.
- Wong, F. M.
- Woodfield, G. L.
- Woodward, M. R.
- Yallalee, W. P.
- Zimmerman, A. W.

Carnegie Institute of Technology

- Ackerman, W. F.
- Avirostek, A. A.
- Benner, G. W.
- Breverman, H.
- Briner, L. D.
- Bryan, R. G.
- Buckman, D. G.
- Challinor, J. R.
- Chyczewski, F.
- Closs, W. J.
- Cooper, H. D.
- Cuffin, R. J.
- Cunningham, K. R.
- Drum, A. G.
- Ekholm, B. O.
- Elliott, G. M.
- Fay, O. C.
- Fives, F. M.
- Floyd, J. F. R.
- Folio, J.
- Giordano, S. R.
- Graham, W. D.
- Hammerschmidt, L.
- Hardin, W. R.
- Hardis, L.
- Heldmann, E. J.
- Hudson, C. F.
- Jesser, A.
- Jones, H. L.
- Knight, A. B., Jr.
- Kotsch, J. A.
- Kreh, E. J., Jr.
- Kritscher, A. F.
- Lambertson, G. W.
- Lefkovics, C. S.
- Loughney, C. E., Jr.
- McCutcheon, K. B.
- McDowell, T. A., Jr.
- McMurry, L. W.
- Makepeace, R. L.
- Meng, E. R.
- Meyer, E. B.
- Moyer, G. E.
- Newbury, P. L.
- Paule, S.
- Platt, R. D.
- Potter, R.
- Raisig, C. C.
- Ratcliffe, T. W.
- Raynovich, W.
- Reisacher, R. M.
- Reynolds, J. C.
- Roach, J. H.
- Rogerson, J.
- Ryshanek, H.
- Salinger, E. S.
- Severn, H. A.
- Simons, E. M.
- Starzynski, S.
- Strohecker, R.
- Virostek, A. A.
- Watson, P. R.
- Weeber, R. C., Jr.
- Williams, J. B.
- Wright, J. A.

Case School of Applied Science

- Adams, W. P.
- Andrews, Z. B.
- Arnold, R.
- Balbach, R. E.
- Bayley, W. S.
- Berlin, J. J.
- Bosworth, R. R.
- Brandes, F. A.
- Cairnes, C. W.
- Capretta, B. A.
- Cerny, R. J.
- Courtot, L. B.
- Davison, C. R., Jr.
- DiTirro, D. A.
- Dunsmoor, J. A.
- Edgar, R. B., Jr.
- Evans, H.
- Feazel, E. A.
- Forbes, W. E.
- Fraas, A. P.
- Frantz, E.
- Fromson, R.
- Geltz, C. F.
- Graham, J. J.
- Helmuth, L. W.
- Herman, R. M.
- Hitz, R. E.
- Hobson, G. W.
- Hoffman, E. C., Jr.
- Iorio, F. F.
- Jamieson, H. R.
- Jepson, A. B.
- Kenerson, V. W.
- Kluge, R. W.
- Kraus, W. R.
- Looney, J. T.
- Lukes, R. H.
- Markley, G. F.
- Marshall, C. W.
- Martinka, P. D.
- Marty, A. H., Jr.
- McCorkindale, J. F.
- Miller, G. P.
- Moeller, R.
- Norte, W. R.
- Pekarek, C. J.
- Riemenschneider, W. K.
- Robbins, J. A.
- Rockwood, P. B.
- Ross, L.
- Schultz, H. L.
- Seaver, W. B.
- Sisler, L. A.
- Snider, W. E.
- Speh, E. J., Jr.
- Splitstone, J. R.
- Staiger, G. W., II
- Stern, A. P.
- Swartz, K. R.
- Truby, W. P.
- Vilmer, F. M.
- Wendt, H. O.
- Wilber, J. J.
- Williams, W. F.

Catholic University of America

- Batchelder, E. B.
- Bayer, A. R.
- Carroccio, S.
- Clune, M.
- Draley, E. C.
- Fehlmer, L. F.
- Gilliam, F. P.
- Glodeck, E.
- Goda, H. L.
- Godfrey, P. J.
- Guryansky, G.
- Hall, G. J.
- Hannan, T. K.
- Lawless, V. N.
- Liccini, J. L.
- Loveless, J. R.
- Middleton, E. L.
- O'Donnell, J. B.
- Phelan, J. J.
- Ropes, J. C.
- Scott, W. R.
- Slaughter, R. K.
- Street, W. G.
- Toomey, J. E.
- Wyble, L. E., Jr.
- Young, F.

Clarkson College of Technology

- Allison, W. H.
- Brown, R. S.
- Cartin, S. F.
- Cross, R. A.
- Darrohn, M. D.
- Darrow, K. A.
- Duce, K. R., Jr.
- Lettice, R. S.
- Nelson, D. G.
- Obrig, R. S.
- Olmstead, A. E.
- Quentin, C. R.
- Raaflaub, H. E.
- Rodger, W. R.
- Smythe, R.
- Snyder, G. E.
- Spencer, E. C.
- Stadler, N. M.
- Wheater, W. W.

Clemson Agricultural College

- Adair, S. W.
- Clark, S. R.
- Crouch, A. C.
- Davis, J., Jr.
- DeWitt, M. R.
- Galvanek, E. J.
- Geisberg, R. L.
- Graham, L., Jr.
- Gray, C. A.
- Jenkins, R. W.
- Jordan, B. S.
- Lewis, J. W.
- Mann, J. T.
- Martin, R. W.
- Motes, M. M.
- Nisbet, J. D.
- Prause, W. K., Jr.
- Prestwood, J. G., Jr.
- Rickards, T. M., Jr.
- Simpson, W. M.
- Stalvey, A. E.
- Varn, J. D., Jr.
- Vaughan, C. R.
- Waldrep, J. E.

Colorado State College of Agriculture and Mechanic Arts

- Axtell, M. E.
- Brown, H.
- Cox, G.
- Crenshaw, W. F.
- Estep, F. D.
- Henderson, D.
- Jennings, U. P.
- Lamm, O. D.
- Sabec, F.
- Scott, C. M.
- Standley, H. B.
- Starkey, J. F.
- Vorhees, R., Jr.
- Vorhees, V. E.
- Wilson, L. V.

University of Colorado

- Ancell, R. M.
- Borchert, R. L.
- Burger, W. H.
- Burnham, G. C., Jr.
- Emery, W. H.
- Fairhurst, G. S.
- Garnett, E. V.
- Gregg, A. R.
- Hardy, L.
- Jensen, E. C.
- Johnson, R. E.
- Lootens, R. K.
- Mathis, W. M.
- Metzger, D. R.
- Moore, C. A., Jr.
- Risley, D. L.
- Thomas, G. C.
- Ware, D. H.
- Wheelock, R. J.
- Wood, C. O.
- Worthington, W. H., Jr.

Columbia University

- Cammen, M. M.
- Celani, P. J.
- Edwards, F. A.
- Elmendorf, W.
- Furman, G. R.
- Gold, I.
- Gongwer, C. A.
- Hillerns, G. O.
- Jaffe, B.
- James, I. G.
- Kiachif, M.
- Massfeller, K.
- McCullough, D. P.
- Mitchell, H. C.
- Modrovsky, J.
- Moore, T. G.
- Richards, W. M. S.
- Rochester, T. W., Jr.
- Steiner, W. A.
- Tessin, W.

Cooper Union

Balk, L. J.
Brady, J. V.
Brushansky, R.
Budde, A. A.
DeMasi, R.
Dmitroff, G. A.
Fitzgerald, G. V.
Gordon, M.
Guzzardi, S.
Hasselbach, A. T.
Horowitz, B.
Jaffe, E.
Kirby, C.
Kleban, B.
Kutzelman, E. G.
Last, B.
Martone, A.
Matiuk, A.
McAleer, J. J.
Middleton, J. F.
Oldham, R. D.
Rankel, R. A.
Robinson, D. C.
Savacchio, A. N.
Schiller, J. D.
Shalita, M.
Stimpson, J.
Sverdlik, J. D.
Swertloff, S.
Vignini, W.
Wales, H. M.
Weber, H. P., Jr.
Webster, L. B.
Weipert, J. J.
Welling, M.
Wild, O.
Winer, B. G.
Wolejsio, W. S.

Cornell University

Albright, C. M., Jr.
Amsler, D. C.
Antrim, J. C.
Baker, J. V.
Baxter, F., Jr.
Bayles, W. H.
Benjamin, D.
Brezina, J. J.
Brewer, E. R.
Brink, W. A.
Buxton, J. E.
Carricarte, A. C.
Ceperley, F. F.
Clark, V. S.
Cooper, J. R.
Davidson, J., III
Day, H. C.
DeWitt, H. F.
Dorr, E. V.
Ehrhart, G. W.
Evans, F. R.
Evans, R. A.
Fish, J. T.
Frick, S. W.
Hammers, W. S.
Herzog, M. S.
Hiltebrant, S. D., Jr.
Jones, W. G., Jr.
Kellogg, R. C.
Kelly, T. B.
Kent, R. H., Jr.
Martinez, S. M.
Mathey, A. VanA.
May, H. S., Jr.
McClennan, J. H.
Menges, R. H.
Merrill, L. P.
Miles, D. B.
Miller, W. W.
Misner, D. M.
Neff, W. J., Jr.
Otto, C. R.
Patterson, G. E.
Philipp, G.
Pleuthner, R. L.
Raisler, H. A.
Robinson, P. C.
Schadler, J., Jr.
Simpson, H. W.
Simpson, J. B.
Sobel, H.
Stolberg, W. G.
Story, R. K.
Wagner, D. E.
Walker, H. L., Jr.
Wattles, E. D.

University of Delaware

Baldwin, E. W., Jr.
Barto, M. J.
Benson, C. C.
Benson, W. K.
Black, J. W.
Cannon, J. G.
Comley, J. C.
Craig, J. M.
Crerand, J. P.
Dailey, A. C.
Davidson, A. A.
Eastman, A. B.
Elliott, J. R.
Furman, J. G.
Gallagher, H. F., Jr.
Gentil, R. V.
Gerow, W. L.
Hatcherson, T. M.
Hull, J. H., Jr.
Jacoby, I. W.
Jamison, F. J.
Keen, W. N.
Lattin, C. P.
Layman, A. H.
Lofink, J. J.
Lomax, E. S.
Nichols, J. F.
Reiver, J.
Richardson, O. L.
Rogers, J. DeW., Jr.
Schwartz, E.
Shinn, W. I.
Smith, C. L.
Stradley, G.
Sunderland, R. N., Jr.
Warren, E. J.

University of Detroit

Addy, J. L., Jr.
Addy, R. C.
Benson, J.
Buczkowski, A. J.
Carville, R.
Chieger, G.
Chont, D. G.
Clary, E. LeR.
Connolly, E. W.
Danahey, T. J.
DePalma, E.
Ernst, F. W.
Fuller, F. J.
Graul, W. E.
Horvath, J. P.
Howard, F. W.
Huetteman, R. T.
Johnson, A.
Kemsley, A. S.
Koch, D. H.
Kuharich, C. N.
Leslie, J. D.
Ludwig, C. W.
Miazga, L.
Moore, R. J.
Musial, J.
Nolan, E. T.
Omelianoff, G.
Patyrak, S. F.
Paul, A. J.
Pitonyak, F. J.
Reigner, H. M.
Ross, T. P.
Sarosiek, A. J.
Schatz, R. M.
Schneider, A.
Sherrin, W.
Smith, S. E.
Stein, R. F.
Vederko, J. P.
Wittig, W. K.
Wood, F. J.
Wozniak, F. B.
Zynda, J. R.

Drexel Institute

Berry, E. H., Jr.
Contole, W.
Cramer, F. M.
Craven, S., Jr.
Csere, S.
Dodge, C.
Elston, C. W.
Foltz, C. J.
Goller, G. N.
Heggan, G. E.
Hess, J. R.
Hutchinson, G. T.
Juram, A. E.
Mattia, M. T.
Mitchell, R. F.
Mitchell, S. McC.
Monell, D. R.
Poisker, J. M.
Powischill, J. W.
Quinn, B. E.
Raynes, S. H., Jr.
Schaeffer, P. A.
Schneider, C. H.
Scott, W. A.
Wurster, G. H.

Duke University

Alberts, J. C.
Alexander, W. W.
Boyce, S. F.
Buckingham, W. H.
Bynum, G. T.
Clark, G. W.
Cornish, D. C.
Cramer, W. M.
Cummings, R. W.
Gregson, J. R.
Hardin, J. C., Jr.
Hatch, J. P.
Hitch, R. A.
James, R. L.
Jerome, W. G., Jr.
Jones, A. S.
Keane, R. C.
Liller, M. H.
Martin, R. D.
Mathews, E. G.
McKee, S. E.
McMackin, F. J.
Nicholas, D. Y.
Parzick, V. J.
Powell, J. R.
Rohland, J. H.
Shilling, E. W.
Stube, W. N.
vonSothen, E. A.

University of Florida

Bassett, W. L.
Bellah, G. W., Jr.
Benjamin, J. P.
Bisson, E. E.
Bonney, E. L.
Eastman, J. M.
George, W. R.
Gordon, H. M.
Harrell, W. H., Jr.
Heim, R. W.
Keller, R. D.
Klotz, K. W.
Koch, T. F.
Koch, W. A., II
Leggett, J. T.
Lister, K. J. D.
Major, A. R.
Mason, C. D.
MacDonough, E. P.
Ormston, A. J.
Redgrave, J. M., Jr.
Remp, G. E.
Roe, C. B.
Toske, W. H.
Tunis, F. L.
Vanderhoek, J. S.
Wallace, A. R.
Warren, R. E.
Waychoff, E. H.

Georgia School of Technology

Barnes, H. S.
Bevis, G. E.
Campbell, H. B.
Carver, W. L.
Cheek, E. E.
Crocker, J. C.
Croley, J. G.
DeMeritt, F. W.
Echelson, G.
Emmert, H. D., Jr.
Fernandez, C. E.
Foulds, G. G.
Glass, J. E.
Haney, P. H.
Harper, W. D.
Hawkins, E. W., Jr.
Hodgdon, F. E.
Holland, L. A.
Holt, A. C., Jr.
Horine, W. W.
Jensen, A. H.
Keyserling, B. H.
Lambert, M. T., Jr.
Lipton, I.
Love, J. E.
McNenney, W.
Miller, A. A.
Munroe, L. R., Jr.
Norton, W. C.
Powell, J. H.
Ramsey, J. S., Jr.
Rhyne, C., Jr.
Schreeder, C. L., Jr.
Shepley, R.
Sinquefield, C. A.
Spencer, L. J., Jr.
Spreen, A. R.
Stone, C. W., Jr.
Taylor, G. C.
Thompson, W. McW.
Walker, B. P.
Wallmeyer, I. H.
Weinstein, H. R.
Willcox, W. L.

George Washington University

Anderson, D. F., Jr.
Ballou, E. J.
Beane, J. R. L., Jr.
Bitner, F. G.
Blew, F. A.
Bransford, C. K.
Burton, P. T.
Carr, R. W.
Connor, H. C.
Dawson, L. J.
Dean, A. P.
Donovan, J. T.
Fielitz, F. J.
Froyd, L. W.
Gareau, C. F.
Green, F. C.
Hoffman, C. O.
Johnston, T. H., Jr.
Keegan, H. J.
King, W. O.
Lane, E. J. H.
Lecraw, J. E.
Matson, R. N.
McKnight, M. N.
Mikuszewski, C. J.
Muth, R. F.
Newell, E. D.
Pfahler, R. D.
Randall, B. M.
Rarey, F. W.
Reynolds, G. F.
Reznek, L. J.
Riggs, W. A.
Roeder, C. H.
Schubert, E. H.
Simmers, R.
Spellman, R.
Strout, R. P.
Thom, H. C. S.
Vorkoeper, D.
Watson, G. B.
Willis, J. B.
Wilson, H.
Woolard, B. W.

University of Idaho

Alsop, C. E.
Atwood, J. P.
Baldwin, R. H.
Caples, V.
Carlson, W.
Coonrod, S. G.
Gauss, J. H.
Gauss, W. H.
Gibbs, J. P.
Griffin, L. W.
Johnston, E. M.
Luukkonen, V. A.
McGee, G. W.
McVey, J. W.
Merrill, B. M.
Moon, L. C.
Moore, J.
Reznor, G. W.
Robinson, F. V.
Schubert, D. LeR.
Stewart, R.

University of Illinois

Ackermann, F.
Arnold, H. E.
Barclay, H. R.
Barker, T. L., Jr.
Beck, C. E.
Beckerle, H., Jr.
Berger, W. A.
Blum, D.
Brown, R. A.
Bruder, H. L.
Chamberlain, O. V.
Cochran, W. K.
Cole, D. H.
Coleman, A. R.
Conron, C.
Cooper, J. A.
Cornell, E. L.
Danielson, L. C.
Daukus, A.
Donnelly, R. E.
Dunn, C. H.
Ellsworth, J. K.
Fogler, H. L.
Gehlbach, L. R.
Grasser, F.
Green, C. B.
Gunn, J. V.
Haines, E. T.
Harding, P. J.
Harszy, C. H.
Harvey, M.
Hess, P.
Hlinsky, M. L.
Hursh, R. W.
Jonak, J. H.
Kleckner, H. F.
Koehler, E. F.
Koesterer, L. F.
Kush, A. J.
Kutner, B. Y.
Lannert, E. F.
Levy, B. H., Jr.
Lockhart, J. D.
Logan, G. H.
Long, J.
Lowry, R. K.
MacGregor, R. A.
McCafferty, D. W.
McCornack, A. E., Jr.
McDonald, B. N.
Marich, F.
Middlesworth, C. M.
Namensky, C. P.
Needham, N. V.
Nolan, E.
Odgers, W. O.
Paradiso, S.
Peters, W. W.
Poppenburg, F. F.
Rasmussen, F. J.
Reeves, J. A.
Rich, W.
Richards, D. G.
Roche, J. J.
Rodwell, R. D.
Ross, H. C.
Rottersmann, M.
Schlie, F.
Scholl, H.
Seip, N. W.
Slonneger, B. K.
Slupik, W. A.
Spalding, J. W.
Stack, R.
Suhr, K. C.
Tarpley, C. E.
Teiber, J. A.
Usalis, F.
Valek, J.
Wall, V. L.
Walsh, W.
Weiss, LeR.
Wellman, E. J.
White, W. R.
Wisegarver, G.

Iowa State College

Ankerstar, A. T.
Arnold, J. W.
Arp, D. C.
Baxter, H. A.
Beatty, G. A.
Bierman, H. J.
Boyd, J. H.
Brandt, J. B.
Byers, G. F.
Carney, K. G., Jr.
Childs, R.
Chinn, R. J.
Clay, C. H.
Codlin, J. B.
Edwards, D. R.
Eno, D. W.
Garretson, O. L.
Gould, M. E.
Haas, L. E.
Hospers, J. W.
Jacobsen, J. J.
Knapp, S. A., Jr.
Madson, W. R.
Manjoine, M. J.
Myers, H.
Neal, T. F.
Power, J. D.
Rae, R. D.
Rasmussen, R. L.
Read, V. P.
Sar, R. A.
Schuldt, H.
Selim, F. E.
Shoemaker, W. H.
Swanson, E. A.
Tramm, G. E.
Tyndale, H. E.
Waddington, L. E.
Wempe, R. H.
Zingg, W. M.

University of Iowa

Adams, M. C.
Adams, M. L.
Bickel, F. D.
Day, R. R.
Fowler, W. D.
Greenwald, D. U.
Hale, R. I.
Hansen, K. E.
Hudson, C. R.
Marek, R. F.
Moser, N. W.
Schaefer, D. G.
Waters, E. W.
Wehmeyer, W. J.
Yuska, L. J.

Johns Hopkins University

Arloff, E. W.
Berngartt, E. S.
Brown, R. J.
Buck, D. E.
Burggraf, J. C.
Clisham, J. T., Jr.
Davies, C. F.
Davis, W. L.
Fax, D. H.
Galloway, J. R.
Gambrill, H. W.
Gough, W. V., Jr.
Hahn, I. H. F.
Hartke, M. J.
Horn, W. T., Jr.
Hughes, R. LeR., Jr.
Ivins, V. S.
Jarman, W. H.
MacWilliams, W., Jr.
Mewshaw, C. T.
Nopper, R. E.
Sholtes, C. E.
Spear, A. I.
Stinchcomb, L. R., Jr.
Taylor, F. J., Jr.
Watkins, G. E.
Wells, H. S., Jr.
Witzell, O. W.
Ziegler, H. A.

Kansas State College

Armstrong, J. D.
Benson, G. H.
Blakslee, P. L.
Buck, N. L.
Carter, C. T.
Claflin, H. K.
Cronin, R. J.
Davenport, H. W.
Deffenbaugh, J. L.
Dukelow, J. S.
Edelen, C. J.
Edwards, R. L.
Ewald, G. B.
Flint, D. K.
Flynn, J. L.
Gough, W. V.
Hamlin, C. P.
Hermon, L.
Hubbs, C. P.
Hunt, A. T.
Hunter, D. T.
Hunter, F. R., Jr.
Johnston, R. C.
Kilroy, M. J.
Lang, D. T.
Link, N. W.
Marschallinger, F. L.
Martin, H.
Matchette, J.
Mock, L. K.
Nielsen, C.
Page, W. C.
Reed, E. E.
Ross, C. F.
Samp, C. F.
Thompson, C. T.
Vick, H.
Warstler, W. H.
Weatherholt, A.
Wheelock, J. R.
Wheelock, W. L.
Wick, D. E.

University of Kansas

Armstrong, R. M.
Ayers, A. N.
Bailey, N.
Barnett, D. A.
Benz, L. W.
Blake, J. R.
Citron, D. J.
Cobb, G. H.
Coleman, R. L.
Detlor, L. T.
Grant, C., Jr.
Gustafson, F. B.
Halstead, R. C.
Hill, W. H.
Jackson, H. D.
James, M.
Johnson, L. M.
Launder, J.
Lucas, C. G.
Marchio, E.
McClain, W. K.
Miller, J. J.
Nottberg, H., Jr.
Russell, R. A.
Smithmeyer, L.
Sutton, R. I.
Thudium, F.
Votaw, LeM. S.
Zeskey, C. R., Jr.

University of Kentucky

Bloom, L. E.
Botts, R. L.
Bryant, L. P.
Carter, M.
Davis, W. E.
DeFilippo, R.
Gebhart, N. I.
Gilmor, J.
Hall, C.
Harmon, W. T.
Hotaling, R. L.
Jackes, H. D., Jr.
Jefferson, E.
Johnson, J. H.
Kress, L. G.
Lowry, W. L.
Mahon, B. M.
McCain, L. H., Jr.
McDowell, C. W.
Menchero, B. A.
Miller, H. M., Jr.
Montgomery, F. J.
Moretti, G.
New, J. C.
Niles, M.
Olney, C. B.
Penn, J. E.
Perkins, J. R.
Reeves, C. P.
Rice, R. I., Jr.
Riley, T. R.
Shanklin, J.
Sheehan, J. J.
Snider, M.
Taylor, J. T.
Traynor, J. H.
Welch, E. G., Jr.

Lafayette College

Breen, E. M.
Bryans, D. R.
Capstaff, P. J. L.
Detjen, E. P. E.
Eleniewski, H. E.
Ford, P. J.
Francis, H. K.
Henderson, E. W.
Hutton, G. S.
Jaqua, G. R.
Land, W. O.
Lathrop, E. S.
McMackin, C. A.
Manieri, P. F.
Marshall, D. H.
Maxfield, E. D.
Meehan, T. T.
Parker, F. W., III
Petura, R. C.
Rauber, G. V.
Young, J. F.

Lehigh University

Ash, W. J., Jr.
Boorman, R. W.
Cooper, E. P.
Curren, A. T.
Doney, W. L.
Freedman, A. M.
Hill, W. W.
Jackson, T. E.
Johnston, W. H.
Juer, R.
Kelly, H. A.
Klingaman, L.
Nissley, S. B.
Orr, G. P.
Patterson, W. P.
Reed, N. G.
Schmoyer, R. L.
Shank, W. H.
Trumpler, W. E., Jr.
Turnbull, W. G., Jr.
Vogelsberg, R. W.
Warnisky, J. V.

Lewis Institute

Baldwin, G. M.
Batty, S. C.
Bilotta, L. V.
Bradley, C. E.
Brendle, J. A.
Byrne, J.
Cole, S. A.
Cramer, W. F., Jr.
Cravener, D. H., Jr.
Decker, R. A.
Deneff, D. D.
Diller, D. E.
Doerr, C. F.
Dufresne, G. J.
Feldman, M. H.
Fennema, C.
Formento, M. J.
Gahan, J. J.
Goldberg, R. A.
Grau, W. S.
Hesson, J. C.
Hinkel, L. H.
Jackett, W. H.
Jacobus, C. E.
Josephson, S. N.
Karez, F. R.
Katerndahl, D. R.
Kendall, N. R.
Kenzel, E. I.
Kizaur, A.
Knott, J. O.
Otten, W. N.
Peickii, V. L.
Reimuller, C. J.
Scharres, J. W.
Schoij, E.
Smith, H. L.
Taylor, F. W.
Vellinga, J.
Vodvarka, F. J.
White, R. A.
Wierciak, T.

Louisiana State University

Battaile, B. B.
Cabrera, W. H.
Carville, D. J.
Cooper, J. A.
Copeland, J. E.
Day, A. D.
Downs, W. R.
Edwards, W. R.
Fredrick, J. L.
Greeson, M. C.
Hathorn, W. R., Jr.
Hoffman, H., Jr.
Hopper, R. J.
Hundemer, C. H.
Kramer, F. B.
Lawrence, S. E.
Lea, M. A.
Luse, W. K.
McEachern, T. H., Jr.
Melancon, M. J.
Memory, R. A.
Montoney, R. L.
Morales, F. V.
Moreland, W. B.
Pace, V. H.
Pizzali, E. R.
Quin, F. W.
Sindo, P. H.
Soler, A., Jr.
Sturges, C. C., Jr.
Tucker, R. B.
Weathers, L. T.

University of Louisville

Bardin, B. C.
Block, S.
Buckle, B. W.
Blunk, J. H.
Drummond, J. A., Jr.
Dupps, R. L.
Ellsworth, G. I.
Garvey, C. S.
Hess, K. G.
Hood, W. H., Jr.
King, J. A.
Klemt, W. W., Jr.
Krause, O. C., Jr.
Leins, R. W.
Lovelace, R. W.
Nicholson, R. L.
Ogden, E. F.
Senior, K. W.
Sibley, H. E., Jr.
Van Overbeke, C. W.
Weigel, R. H.
Weller, D. F.
Witherspoon, D. L.
Wuest, G. E.
Wuest, W. D.

University of Maine

Bryant, E. D.
Crowell, W. E.
Ellingson, A. M.
Felberg, L.
Folley, C. W.
Harvey, R. W.
Larrabee, E. W.
Litchfield, L. P.
Mader, G. H.
Osgood, C. C.
Sumner, M. R., Jr.
Thayer, A. L., Jr.
Vannah, S.
Wilson, N. J.
Williams, G. S., Jr.

Marquette University

Brauer, R. C.
Eberle, J. J.
Feichtinger, W. R.
Griesberg, M. W.
Hartley, C. S.
Hennings, E.
Koes, F. L.
Krause, C. H.
Losse, W. H.
Macdougall, I.
Meidel, C. F.
Mierzwa, L. E.
Potter, R. W.
Stromberg, M. J.
Swette, G. J.
Thomes, E. J.
Weber, J. H.

Massachusetts Institute of Technology

Abbott, S. L.
Aksomitas, W. E.
Aldrich, J. W.
Argersinger, J. I.
Baker, F.
Bartholomew, E. L., Jr.
Benson, R. E.
Berg, Q.
Brod, B.
Case, W. E.
Caulder, J. W.
Chapin, R. B.
Christie, R. E.
Cook, J. R.
Crapon, H. D., Jr.
Derzawetz, J.
Dierksmier, C. M.
Dodge, C. O.
Dreissigacker, P. H., Jr.
Duncan, J. R.
Emerson, B. C.
Engel, J. M.
Ferrary, F. F.
Forde, I. W.
Freiberg, J. M.
Gander, J. H.
Gerson, M.
Goddard, W. B.
Goodwin, K. P.
Graffeo, A. J.
Greenberg, J. H.
Grigorieff, V. J.
Gumprich, W. C.
Gunkel, K. M.
Gwatkin, W. E.
Hadley, G. E.
Haley, H. P.
Hallenbeck, T. L.
Hanlon, J. J.
Heacock, R. C.
Heintz, A. P.
Henes, C.
Hochman, E.
Hrones, J. A.
Jacobs, M. E.
Johnson, W. A.
Karch, R. G.
Kaufman, W. F.
Kearny, F. J.
Kieley, T. J.
Kramer, L. J.
Kron, R. V.
Kuban, M.
Maguire, J.
McCuen, M. D.
McGregor, J. E.
McKee, J. W.
Mandelkorn, R. S.
Metzger, M. I.
Morrisson, R.
Mott, G. C.
Muther, R.
Neumann, E. P.
Nie, K.
Nugent, J. B.
Obrig, J. T.
Olmstead, E. H.
Olsen, C. E., Jr.
Palmer, W. M.
Paull, J.
Peterson, E. C.
Poon, Y.-P.
Pratt, R. W.
Reinhardt, A. E.
Rowe, H. A.
Ross, C. W.
Rudzinsky, S.
Scalinger, C. R.
Schondorff, B.
Sebell, A. L.
Sessler, R. E.
Shapiro, A. H.
Smith, H. T., Jr.
Smith, J. A.
Smith, R. W.
Starr, C. J.
Summerfield, J. R.
Sun, W. I. T.
Swain, H. D.
Swain, K. W.
Tsiang, S. H.
Turner, R. S.
Wagner, E.
Walker, R. K.
Walter, S. T.
Waterman, D. W.
Webb, J. C.
Welch, L. E.
Wiley, H. A., Jr.
Williams, C. A., Jr.
Winter, M. A.
Wochos, W. M., Jr.
Wolin, R. H.
Wong, C.-C.
Wu, Y. Y.
Young, G. R.

Michigan College of Mining and Technology

Berry, A. L.
Berry, J. L.
Bohnhoff, A.
Cadwell, A.
Carnegie, G.
Chapman, D.
Clemens, J. D.
Counselman, T., Jr.
Davis, G.
DeFouw, T.
Hall, C.
Herrmann, W. F., Jr.
Howard, M.
Jacques, C. J.
Johnson, A. B.
Jorgenson, H.
Juntenen, G.
Kennedy, D. H.
Kleptko, E.
Krans, D.
Loon, F.
MacDonald, R. J.
Maki, E. A.
Marttinen, R. E.
McNally, H.
McPhail, J. D.
Messner, M., Jr.
Mlinaz, J. P.
Moffat, J. W.
Munson, E.
Niemi, C. H.
Niemi, E. W.
Olson, C.
Ouellette, C.
Owens, A. P.
Petaja, A. E.
Polderman, R.
Real, J.
Roberts, E. E.
Schnaufer, M. F.
Seidl, L. M.
Sydanmaa, W.
Thorpe, S. C.
Trontell, J.
Weaver, H., Jr.
Williams, R. V. O.

Michigan State College

Anderson, M. R.
Armstrong, L. M.
Ashley, C. M.
Austin, J. H.
Ballenger, J. M.
Barringer, G. L.
Barthold, R. J.
Bingham, J. S.
Boyko, J.
Bristol, R. W.
Brooks, R. E.
Brundage, J. E.
Burke, C.
Carapella, L. A.
Carlson, O. H.
Christian, C. G.
Clark, S. A.
Clough, R. C.
Collins, J. D.
Coriell, R.
Cox, O. S.
Dahlberg, W. G.
Dow, G.
Fairbanks, S. J.
Fangboner, H. F.
Frederickson, A. O.
Goddard, M. B.
Godfrey, J. R.
Habrle, L. A.
Hamann, J. R.
Hammerstein, R.
Hickey, R. P.
Hunter, C.
Huntley, F. H.
James, D. T.
LaRocque, A. E.
LeTart, H. J.
Lewis, M. C.
Lundgren, C. S.
Madison, R. H.
Maring, J. A.
McSorley, D. C.
Moses, R.
Mueller, C. T.
Ogden, F. H.
Paeplow, W. W.
Robinson, R. W.
Sangster, J. McC.
Scheid, P. E.
Sebaible, I.
Smith, C. C.
Smith, E. W.
Smith, M. R.
Sparling, P. W.
Taylor, W. R.
Trembath, R. S.
Van Dine, D. C.
Van Zyl, H. J.
Weber, R. E.
Weprin, H.
Wilson, D. R.
Zink, A. H.

University of Michigan

Anderson, C. R.
Barecki, S. H.
Barnes, H. E.
Bartnik, S. R.
Beebe, L. W.
Berryman, J. I.
Berryman, L. G.
Blakley, W. R.
Block, C. L.
Bluford, G. S.
Boer, E. J.
Bradford, G. J.
Bush, S. W.
Carlzen, C. F.
Carson, D. E.
Cheney, G. W.
Chew, Y. P.
Cleveland, R. O.
Cole, A. T.
Conlon, W. L., Jr.
Cook, G. G.
Cowdrey, T. O., Jr.
Crusey, H. W.
Curriston, L. E.
Daniels, M. G.
Danse, R. A.
Dery, J. A.
Diaz, J.
Dibble, H. L.
Dubord, A. J., Jr.
Elliott, C. M.
Emley, W. E., Jr.
Engstrom, J. E.
Eshelman, R. L.
Farrah, J.
Gay, L. H.
Goloff, A. A.
Graf, K. L.
Green, C. R.
Griffin, R. D.
Hammersmith, G. W.
Haskins, C. N.
Hillier, D. E.
Humenczuk, W. M.
Hyatt, M. G.
Ilyin, B. P.
Ingold, J. F.
Ipsen, P. G.
Jackson, C. H.
Jacobson, C. N.
Janson, R. O.
Janura, H. C.
Jennings, F. A.
Jewell, W. H.
Kempton, J. V.
Khatib, I. A. K.
Klonoski, S. W.
Knott, J. E.
Krans, P. F.
Lansdale, D. B.
Leonard, V. K.
Lewis, R. E.
Lewis, S. C.
Luthe, H. P.
MacLeod, W. J., Jr.
Mason, J. M., Jr.
Mc Anulty, J. C.
McCarthy, G. S.
McFayden, N. G.
Mitchell, W. H.
Murdock, J. H.
Northway, G. A.
Oliver, J.
O'Neil, L. E.
Peterson, R. J.
Phelps, G. W.
Pomeroy, D. A., Jr.
Proos, G. M.
Rashleigh, W. A.
Reid, R. A.
Robinson, J. I.
Rohde, E. C.
Rubin, A. E.
Ruettinger, T. O.
Samborski, C.
Sinclair, E. L.
Spencer, R. L.
Spitzley, J. H.
Spitzley, R. L.
Stehle, P.
Sterner, M. F.
Sterner, W. A.
Stevens, J. M.
Stuart, G. N., Jr.
Sutin, H. A.
Tang, S. L.
Tann, G.
Tarte, R. J.
Taylor, H. E.
Taylor, M.
Teeter, W. M.
Theobald, P. E.
Townsend, D.
Valk, R. E.
Van Loo, C. G.
Wagner, J. C.
Walker, J. H., Jr.
Wangelin, R. S., Jr.
Welch, T. D.
White, R. C.
Wilson, P. W., Jr.
Young, J. G.
Young, R. S.
Yu, S. L.
Zapp, G. M.
Zuris, P.

University of Minnesota

Alinder, G. L.
Anderson, A. A.
Anderson, I. L.
Baer, H. C.
Bennett, M.
Carlson, K. A.
Comb, F. R., Jr.
Cornwall, E. K.
Davies, J. G.
Doxey, H. E.
Faith, H.
Filbert, K.
Finger, S. W., Jr.
Freberg, C. R.
Friederici, G. A.
Funke, L. A.
Gendein, S.
Graham, H. M.
Haglund, G. O.
Hankee, R. E.
Hansen, W. O.
[illegible], K. T.
Hoagberg, W. C.
Johnson, V. A.
Lee, M. L.
Lien, W. A.
Lightowler, J.
Lindholm, R. V.
Lowen, P. O'C.
Lykken, H. G., Jr.
Manly, R.
Matey, W.
Matthies, A. C.
Meyers, R.
Mitchell, G. T.
Mooney, R.
Morse, C. R.
Nelson, C. M.
Olson, W. A.
Ostdahl, H. E.
Paine, H. A.
Peterson, J. R.
Pfleider, R. E.
Pierson, E. D.
Pitts, Z.
Prosser, R.
Renstrom, F.
Rintala, E. F.
Romanchuck, N. A.
Sacco, C.
Schad, C.
Serigstad, N. R.
Shotwell, D. B.
[illegible]
Smith, K. F.
Snyder, W. A.
Swanson, A. W. O.
Swanstrom, A. H.
Teeter, R. T.
Towner, C. E.
Tucker, C. H.
Warner, F. P.
Webb, W. L.
Winn, G. S.
Wolfe, W. W.

Mississippi State College

Buckingham, H. B.
Carruth, U. J.
Cooper, H. V., Jr.
Courtney, W. O.
Crane, H. O.
Friend, A. B., Jr.
Gr[illegible], B.
Grohoski, C. J.
Holaday, C. E.
Hughes, E. B.
Keary, W. I.
Marx, W. N.
May, E. A., Jr.
Mays, S. W.
Mollere, L. A.
Montgomery, B. S.
Musselwhite, W. B.
Norman, J. R.
Pearson, W. B.
Rogers, V. J.
S[illegible], O.
Stampley, O. K., Jr.
Stevens, W. A., Jr.
[illegible], J. R.
Weems, G. S., Jr.
Welch, P. W., Jr.
Whelan, J. W.
Whiting, G. D.
Wilkinson, C. L., Jr.
Williams, J. R.
Williamson, J. F.

Missouri School of Mines and Metallurgy

Alexander, M. S.
Bochenek, A. F.
Ellis, J. C.
Ellis, P. B.
Gerwin, H. L.
Goellel, W. L. W.
Haacke, G. W.
Hauck, L., Jr.
Holz, W. L.
Jaenecke, D. R.
Kaley, R. R.
Luder, W. E.
Maloney, W. G.
Mollet, H. W.
Moore, J. C.
Moore, W. T.
O'Neal, J. W.
Phillips, A. A.
Price, S. R., Jr.
[illegible], A. K.
T[illegible]er, B. V.

University of Missouri

Bates, H. K.
Baugh, H. H.
Brand, J. R.
Briggs, C. B.
Burnett, E.
Crum, J. L., Jr.
Dickinson, S. S.
Douglas, B. C.
Fallin, E. A.
Flanery, B. K.
Fleischaker, R. H.
Flowers, W. H. B.
Gettinger, L. A.
Gratsch, H. L. A.
[illegible], D. F.
Havel, F. L.
Hill, J. J.
Holt, C. C.
Ketter, H. E.
Martin, J. A.
Minchenberg, E.
Moore, E. B.
Moorehead, J. R., III
Perry, W. M.
Satterlee, H. A.
Teel, C. L.
Thompson, T. O.
Thurlo, J. A.
Trowbridge, I., Jr.
Vincent, J. H.
Wanner, C. A.
Wolpers, H. M.
Yedlin, M.

Montana State College

Cowles, L. B.
Hilts, I. F.
Kennedy, R. A.
Knoll, J.
Martin, [illegible]
Reed, G. W.

University of Nebraska

Bachman, G. G.
Bacon, W. H., Jr.
Bartling, H.
Berg, W. B.
Brown, H. E.
Brown, H. W.
Buckendorf, L. H.
Cadwell, G. H.
Carlson, C. E.
Chowins, R.
Dalby, V. L.
Edwards, T. M.
Erb, J. H.
Ferguson, J. C.
Floor, U.
Gaffney, D. J.
Galloway, R. M.
Gamlin, P. J.
Garrison, M. R.
Hamley, G. O.
Hammond, W. H.
Hanthorn, G. W.
Howe, C. F.
Hull, H. E.
Humphrey, P. E.
Hunt, J. H.
Jensen, H. H.
Johnson, R. D.
King, R. R.
Koch, P. H.
Leymaster, I. L.
Lien, A.
Lundstrom, L. C.
Mac Donald, J. W.
Mercier, J. G.
Morrow, J. H.
Ostwald, R.
Parsell, R.
P[illegible], J. E.
Payne, D. I.
Pearson, H. B.
Pollard, T. J.
Sanders, L. H.
Sanderson, H. E.
Schreiner, J.
Schultz, W. A.
Smith, E. G.
Spencer, T. E.
Struthers, K.
Tefft, W.
Thomas, P. H.
Tupper, J. K.
Uehling, [illegible]
Wallace, [illegible]
Whitehead, G.
Wimer, R. H.

University of Nevada

Allen, C., Jr.
Atkinson, J. A.
Burt, C. A.
Cash, R. A.
Elkins, W. H.
Fairhurst, K. S.
Folsom, E. R.
Ford, E. T.
Marean, J. H.
Morris, G. P.
Morris, T. Q.
Scott, V.
Smith, H. N.
[illegible]
[illegible]
[illegible]

Newark College of Engineering

Altounian, R.
Amo, I. J., Jr.
Anderson, W. G.
Backity, S.
Bailey, J. T.
Barton, M.
Beaudette, P.
Becica, C.
Boczar, H. P.
Booth, H. R.
Bowman, R. W.
Breisford, H. A.
Brolo, F. A.
Bronk, A. H.
Brunkhardt, F. W.
Burke, A. J.
Buxton, J. C.
Carlson, P. E.
Chankalian, R.
Cleveland, R. E.
Crocker, K. G.
Daubner, R. E.
DeFeo, A.
deHaven, F. I.
deParrie, E.
Dietz, E. A.
DiLiberti, E.
Dobbins, R. N.
Dolan, R. M.
D[illegible], J. F.
[illegible], H.
Ferreira, N.
Florentine, M. R.
F[illegible], H., Jr.
Foster, R. B.
Francis, E. T.
Franck, R. E.
Franke, K. J.
Frederick, H. S.
Frohboese, R. H.
Godfrey, N. M.
Greenberg, H. J.
Gross, B. D.
Grundman, R. W.
Grygotis, W. J.
Gudmundson, G. G., Jr.
Guenther, M. J., Jr.
Guinee, E. J.
Hausmann, W.
Haythorn, J. W.
Heath, A. F.
Herman, T. A.
[illegible], C. B.
Hind, J. H., Jr.
Holmgren, R. G.
Hopkins, J. R.
Houston, L. F.
Jasnosz, B. J.
Kreitler, F. C., Jr.
Lyons, R. E.
Maguire, E. L.
McEligot, M. J.
Moser, B. P.
Moskowitz, W.
Muench, E. J.
Nagel, W. H.
Nezbeda, E. C.
Northrup, F. B., Jr.
Ohar, T.
O'Mara, E. A.
Pasternak, S. J.
Pietrucha, V. F.
Pitt, W. A., Jr.
[illegible], L. S.
Popiel, W.
Quackenbush, W. R.
R[illegible], G. P.
Roosen-Raad, T.
Rosenfeld, A.
Rothbart, H. A.
R[illegible], J.
Schenck, E. G.
Schlechman, S.
Schmachtenberg, E.
Sell, W. H.
Sharkey, J. F.
Shimonis, F. A.

Skarbek, H. F. J.
Slomowitz, J.
Smith, I. M.
Stefany, W.
Stieber, S.
Tench, A. H.
Umowski, J. S.
Uritis, J.
Valentine, T. F.
Vito, E. F.
Wackenhuth, W. E.
Waliace, R. W.
Watts, S. S.
Weigand, R. D.
Weis, H. S.
Whitney, F. J.
Wilkinson, R. B.
Woerz, F. H.
Wood, O. W.
Wygovsky, R. N.
Young, A. P.
Zarnowski, F. H.
Ziger, J. A.
Zimmermann, W. F., Jr.

University of New Hampshire

Bumford, F. H.
Caldwell, W. F.
Carter, R. H.
Clement, R. W.
Davis, C. E.
DuBois, R. A.
Farmer, W. P.
Gates, H. H.
Giarla, T. C.
Goodwin, C. L.
Henderson, G. K.
Herlihy, T. J.
Ingham, G. L.
Johnson, F. H.
Mason, G. K.
Moore, L. S.
Moscardini, A. A.
Ricker, G. W.
Rice, C. S.
Simpson, A. H.
Smith, R. C.
Tomkinson, S. E.
Waldo, S. C.
Weatherby, A. M.
Whitcher, L. G.
Wilbur, H. E.

University of New Mexico

Benischek, H. W.
Bergan, D. K.
Biddle, W. A.
Cooper, L.
Davis, C. G.
Draper, N. M.
Duncan, J.
Erlandson, L. E.
Gibbons, F. C.
Grandjean, G.
Koch, L.
Marr, L. C.
Matthews, B. S.
McGhee, D. A.
Stine, K. E.
Whitesides, J. A.

College of the City of New York

Aaron, C.
Adler, G.
Andara, J. L.
Bermeo, C. H.
Braverman, J. H.
Castellini, D.
Chazer, A.
Dietrich, A.
Doyle, J.
Fischbach, J.
Friedman, K.
Friedman, M.
Gerla, M.
Glowaski, F. E.
Grabin, S.
Hofstein, L.
Hymawitz, E.
Jaffe, B. S.
Jaspen, N.
Jago, L.
Kaplan, G.
Kaner, H.
L'Allemand, G. W., Jr.
Lapidus, S.
LiCalsi, A.
Macaluso, F.
Markowitz, M.
Miller, H.
Palchik, E.
Palese, R. P.
Ricci, G.
Schmelz, W.
Sharko, S.
Shoiket, H.
Steinman, H.
Weiss, A.
Wong, J. C.
Zirin, M. J.

New York University
Aeronautic Division

Alperin, M.
Buck, R. S.
Chapman, J. R.
Cravero, J. A.
Ditson, J. D.
Dunay, D.
Fuetsch, F. T.
Holback, G. E.
Horowitz, S. M.
Ioppolo, A.
Kornberg, G.
Lehr, R.
Lenkowsky, E.
Meshejian, J. M.
Newberger, E. S.
Pass, H. R.
Santucci, L. F.
Schaub, C. H.
Scheinberg, H.
Sellis, R. W.
Siltanen, J. C.
Wallis, G. B.
Wishnitz, S.
Worman, J. G.
Young, J.
Zarkowsky, W.
Zinberg, H.

New York University
Mechanical Division

Ain, J.
Anastasi, N. J.
Friton, J. F.
Gracik, J. W.
Grey, W. L.
Healy, C. J.
Imm, J. J.
Jaros, Z.
McCready, L. S.
Mueller, R. L.
Nack, J. M.
Nelson, E. W.
Noeger, S.
Russo, G.
Swensen, L. K.
Tackney, G. J.
Tanenholz, L.
Wegbreit, J.

New York University
Evening Division

Berg, M. J.
Ciszewski, J.
Cote, O. H., Jr.
Darlington, J. E.
Faber, P.
Greco, A. E.
Grimberg, J. C.
Habit, E.
Hohnecker, O.
Holden, A. C.
Krauss, W.
Lindberg, B. A.
Litvin, N.
Macchi, S. A.
Mascolo, B.
Naiman, J.
Panitz, A.
Petruzzi, C. E.
Resnikoff, W.
Roberts, E. E.
Schwartz, N.
Shepard, E. B.
Steinfeld, M. E.
Trifari, W.
Uhlig, E. C.
Waters, E. H.

North Carolina State College

Abbott, F. T., Jr.
Abraham, L. H.
Bayne, C. R.
Beardslee, A. N.
Bell, G. J.
Betts, G. E., Jr.
Bishop, J. E.
Bloodgood, R. M.
Bourne, R. G. B.
Britt, R. W.
Connell, F. L.
Crawford, H. R.
Fisher, W. H.
Foster, J. M.
Goad, T. G.
Gray, C. J.
Green, P.
Griffith, D. W.
Guerrant, E. L.
Hollis, J. W., Jr.
Holmes, S. C.
King, D. C.
LeConey, H. M., Jr.
Loomis, W. E.
Loos, R. A.
Meekins, M. H.
Mitchell, R. H.
Monroe, R., Jr.
Overman, H. S., Jr.
Pinkham, J. R.
Rogers, S. D.
Speer, W. A.
Thompson, F. N.
Ward, L. A.
Waynick, D. T.
Willis, M. D.
Willis, R. L.
Wilson, T. W.
Woodard, W. W.
Ziglar, F. C.

University of North Carolina

Cate, E. R.
Francis, J. S.
Fraser, G. R.
Henderson, D. E.
Herring, E. L.
Hyde, A. P.
Johnson, W. D.
Kephart, W. P.
Miller, J. A.
Myrick, J. F.
Osborn, K. D.
Robbins, H. E., Jr.
Shiller, L.
Ullman, F. E.
Wagstaff, H. McG., Jr.
Woods, P. H.

North Dakota State College

Cook, J. M.
Dimunation, J.
Hudson, M. O.
Krebsbach, D. V.
Lee, E. L.
Martinson, E. B.
Peterson, R. I.
Sawby, C. J.
Schulz, R. W.
Sundfor, A. H.
Vogel, W.
Vollrath, E. W.
Walberg, M. E.
Ward, D.
Zbytovsky, A. A.

University of North Dakota

Barrows, G. L.
Day, L. W.
Ebbe, G. K.
Goodwin, G. L.
Greeley, C. E.
Gustafson, R. L.
Johnson, R.
Kleven, W.
Lefourneau, S. D.
Nelson, L. S.
Rygh, B. F.
Strand, A. F.
Ziegenhagen, M. E.

Northeastern University

Beck, A. C.
Besse, G. L.
Bednar, J.
Bembl, W. M.
Bowman, S. B., Jr.
Burzyk, E. F.
Cassola, C. A.
Cerant, D. P.
Cooke, S.
Crescenzo, F.
Curcio, A. P.
Curran, J. R.
Cussen, V. I.
Datz, J.
Diamondstone, W. J.
Dow, E. D.
Eames, E. N.
Epstein, W.
Fennell, A. R., Jr.
Ferguson, R. I.
Gaboriault, N. A.
Grant, C. T.
Grela, M.
Gredsky, L.
Hamill, J. R.
Hancock, C. F.
Hill, S. T.
Humphrey, N. V.
Kep, P. E.
Leck, G. C.
Lengel, A.
Lowd, E. N.
Luck, H.
Oakes, A. E.
Packard, S. W.
Patch, A. E.
Pfeiffer, R. L.
Reed, G. A., Jr.
Salecker, A. G.
Shames, A. A.
Slotnick, B.
Tilden, G. R.
White, B. C.
Wilder, H. C.
Wilson, J. A.

Northwestern University

Alexander, C. C., Jr.
Becher, C. C.
Black, J. B., Jr.
Gordon, D.
Gridley, J. B.
Hales, D. E.
Hulben, R. D.
Klinge, E. R.
Munson, L. J.
Pisors, R.
Salamon, A. J.
Schiff, R. J.
Scholz, H. H.
Snyder, J. H.
Tegtmeyer, R. C.
Vye, J. H.
Winther, J. B.
Wolff, R. E.

University of Notre Dame

Barker, P. F.
Davis, J. F.
Delaney, R. H.
Fitzgerald, T. M.
Fitzgerald, W. F., Jr.
Flanagan, E. J., Jr.
Hartz, B. F.
Heinemann, H. E.
Jehle, J. L.
Kesicke, F. E.
Maehler, A. R.
McNamara, J. E.
Minarick, J. W., Jr.
Moore, E. J.
Mullen, E. P.
Penrose, J.
Riley, J. A.
Schmidt, S. J.
Schram, R. A.

Ohio Northern University

Adam, P. W.
Allensworth, J.
Casselman, D. R.
Clark, H. C.
Fowler, A. W.
Lehtonen, T. L.
Leisenheimer, R. H.
Milliron, E. L.
Salo, I. E.
Shannon, W. R.
Strayer, S. C.
Vickio, L. P.
Wertheimer, J. J.
Wojner, W. W.
Youngman, E. F.

Ohio State University

Baugh, E. L.
Bayliss, B. P.
Boebinger, E. J.
Boyer, R. M.
Clark, R. E.
Daberko, W. A.
Darrow, K. G.
Deemer, K. C.
Eagle, J. H.
Fromm, E. H.
Getz, D. L.
Hall, C. A.
Hanger, S.
Haywood, P. G.
Iles, V. L.
Kahn, R.
Kiese, A.
Kinsey, J. C.
Kuntz, W. H.
Lynn, C. D.
McClurg, S. A.
McPherson, E. E.
Nice, H. E.
Purdy, J. B.
Richards, T. E., Jr.
Robbins, H. W.
Rowland, G. E.
Sands, H. J., Jr.
Sawyer, J. W.
Schlub, C. F.
Shuttleworth, C. H.
Sutton, R. W.
Turner, H. B.
Zinn, R. W.

Oklahoma Agricultural and Mechanical College

Allbert, V. P.
Brant, V.
Bretz, R. M.
Combs, A. L.
Denham, F. R.
Dunning, E. A.
Eaton, R. A.
Gamble, H.
Griffin, R. E.
Harrell, J.
Hodgson, A. R.
Hodgson, H. A.
Johnston, M. S.
King, J. A.
King, W. B.
Lorette, W.
McEwen, R.
Manton, F. L.
Markenson, G.
Maxey, W. LaV.
Milliren, LeR. L.
Morey, E. E., Jr.
Pittman, F. C.
Reddick, A. W.
Selfridge, R. N.
Shrock, H. V.
Stinson, L. B.
Thurman, A. L.
Turrill, G. O.
Weaver, I. M.
Williamson, J., Jr.
Wise, M. R.
Young, E. C.

University of Oklahoma

Head, A. J.
Woodward, R.

Oregon State Agricultural College

Allen, R. H.
Anderson, A. W.
Barmettlor, M. L.
Beeson, S. W.
Boner, J. H.
Byers, I. L.
Carl, M. E.
Crocker, M. C.
Cunningham, G. M.
Dean, C. R., Jr.
Forster, T. R.
Greenough, H.
Hackett, R. N.
Harrington, W. L.
Higgins, P. R.
Jacobson, B. W.
Johnston, F. W.
Kelley, S. R.
Klein, L. M.
Komure, S.
Krehbiel, H. C., Jr.
Montgomery, J.
Moore, E. H.
Nelson, O.
Nicol, A.
Peck, E. R.
Rice, L. L.
Rosenberg, A. A.
Sagar, P. B.
Sawyer, W. M.
Smith, B. M.
Stover, W. H.
Wong, G.

Pennsylvania State College

Angstadt, J. W.
Baver, A. A.
Blake, W. H.
Breisch, P. R.
Brumbach, R. E.
Brumgard, LaV. S.
Burleigh, G. D.
Burns, L. G.
Burtner, G. P.
Calvin, J. H.
Corman, W. W.
Davenport, W. P.
Dennis, J. H.
Evans, C. E.
Fandel, W. H.
Fisher, D. F., Jr.
Garey, R. E.
Gresko, J. J.
Harris, W. W.
Hartman, J. H.
Heffelfinger, R. D.
Horne, F. J. T., Jr.
Hugo, M. D.
Ingraham, G. A.
Irwin, J. W.
James, R. T.
Jedrziewski, C.
Johnson, F. M.
Knapper, T. G.
Kohlhepp, D. H.
Krakower, A. M.
Krumreich, C. L.
Kubacki, W.
Laughlin, J. S.
Lucas, J. W.
Lundberg, V. E.
Mac Nair, W. H.
Mentzer, R. B.
Miles, J. M.
Miller, K. F.
Morris, R. B.
Mowry, G. R., Jr.
Mueller, C. L.
Myers, C. L.
Palmer, John LeR.
Ralston, J. A., Jr.
Ritter, G. H.
Saia, B.
Showers, W. F.
Sloan, T. F.
Smith, G. P.
Stratton, J. A., Jr.
Synkonis, J. A.
Taylor, H. N.
Villforth, F. J., Jr.
Walter, A. D., Jr.
Walters, R. M.
Way, W. D. D.
Weigel, J. W.
Whisler, J. H.
Wilson, W. S.
Yoder, A. W.
Young, F. R.
Zimmer, W. J.

University of Pennsylvania

Bates, A. E.
Bates, R. E.
Berman, B.
Bernstein, H. J.
Bobb, W. S.
Brick, G. S.
Brow, W. E., Jr.
Bryans, H. T.
Buchholz, C. D., Jr.
Cain, G. W.
Carson, G. W., Jr.
Criswell, J. C., Jr.
Derby, R.
Doering, J.
Doll, G. J.
Duerr, C. F.
Dutton, W. G.
Fell, A. D., Jr.
Finkel, J. B.
Godshalk, R.
Gordon, S.
Graf, J. R.
Harbeson, G. M.
Hartman, W. W., Jr.
Harvey, E. L.
Jewson, H. F., Jr.
Johnson, H. C.
Keller, C. S.
Kesselman, S.
Klapper, E.
Levin, B. S.
Lewis, W. A.
Lucas, H. N., Jr.
Menkin, D. D.
Mullen, T. Y.
Nicholson, G. N., Jr.
Parker, E. H.
Quigley, J. L.
Raboff, A. S.
Raigvel, W. M., Jr.
Sheppard, R.
Varlan, N. G.
Werngren, M. S.
Wiggins, M. E.
Wood, F. J.
Zisserman, J.

University of Pittsburgh

Ambro, G. W.
Ashcom, R. C.
Avbel, J. A., Jr.
Bell, J. A.
Beltz, C. R.
Benson, S. W., Jr.
Berarducci, E.
Bingham, O. K., Jr.
Cadwallader, R. T.
Campbell, A. B.
Davis, J. E.
Dougherty, C. K.
DuFresne, L. P.
Felder, A.
Ferguson, A.
Freeburg, R. L.
Fuller, S. H.
Garrahan, T. F.
Gracey, W. R., Jr.
Gradisar, A. A.
Green, L. E.
Hammerle, C. B., Jr.
Havekotte, C. J.
Hoover, C. S.
Howath, G. E.
Ilsley, R. H.
Ivanovic, N. P.
Kopec, C.
Kurtz, P. J.
Lisotto, C.
Louder, W. H.
Lux, W. G.
Maloy, H. E., Jr.
McHenry, R. W.
Mc Quillan, W.
Mester, C. H.
Michel, G. G.
Millar, R. B.
Regina, M.
Rowe, L. C.
Schindler, D. B.
Seegan, G. A.
Seigel, L. J.
Simpson, G. R.
Snyder, R. P.
Statler, C. W.
Stiranka, J.
Thomas, E.
Underwood, C. J.
Upson, R. S.
Vatz, I. P.
Wagner, B. D.
Wallisch, A. J.
Weldin, W. J., Jr.
Wigman, H. W.
Witkowski, E.
Zalovcik, J. A.
Zellers, W. H.

Pratt Institute

Armstrong, J. T.
Arns, W. H.
Barbieri, J. D.
Barkan, H.
Benson, P.
Bingham, C. W., Jr.
Brueggeman, C. F.
Burns, H.
Cande, F. W.
Carmody, J. V.
Centofanti, D.
Clothier, H.
Connor, R. C.
Cowan, P. M.
Curry, E.
Dahl, G. W.
Dautrich, G. U.
DeFeo, V. J.
Demange, R. C.
Dyckman, C. A., Jr.
Earl, J. T.
Elzea, D.
Farinella, A.
Ferrea, E. J.
Fiala, F. W.
Freer, W. A.
Gambaro, C. A.
Harrington, C. F.
Havemeyer, H.
Hegner, A.
Henry, A. P.
Judd, W.
Lehnhardt, A. R.
Mattson, A. J.
McCutcheon, D. C.
Miller, E. L.
Mulveny, F., Jr.
Nadeau, Robt. F.
Olsen, C. A.
Pantas, L. J.
Peterson, S. H.
Pfeifer, B. H.
Piazza, E. L.
Ronne, B.
Roth, A. W.
Ryan, A. S.
Salmon, G.
Schlener, H. E.
Schrengauer, E. B.
Schulze, K.
Scott, R. A.
Seith, W.
Semchuk, P.
Shaw, R. A.
Shea, T.
Sheffield, R.
Shelley, Van C.
Sikorski, A. J.
Smith, W. I.
Taylor, J. D.
Thomson, J. B.
Turnbull, D. E.
Ulzheimer, C. J.
Vafides, J.
Woodger, G. E.
Wright, W. P.
Zabriskie, A. E.
Zehnder, C. A.
Zjawin, J. C.

Princeton University

Arnold, W.
Augustine, D. C.
Beers, T. S.
Carey, C.
Carter, J. L., Jr.
Charlesworth, R. B.
Dean, M. H.
Graham, C. R.
Johns, W. L.
Johnson, A. P.
Johnston, A. R.
Kraemer, J. F.
Long, M. C.

McElroy, G. S.
Price, A. M.
Rautenstrauch, R.
Rudd, J. K.
Stanley, R. W., Jr.
Steinsieck, J. M.
Warner, W. M.
White, J. H., Jr.
Williams, C. W.
Wilmer, J. W.

University of Puerto Rico

Acevedo, J. H., Jr.

Purdue University

Adams, F.
Alden, C. J., Jr.
Ammerman, J. McD.
Baals, D. D.
Baase, F. C.
Bassett, C. E.
Bice, G. W.
Bowen, J. D.
Bublitz, C. A.
Carbon, H. B.
Carson, D. H.
Carton, R. F.
Chapp, H. J.
Chenoweth, D. M.
Chew, L. W.
Clutter, C. E.
Compton, W. C.
Conway, J. G.
Cooper, R. S.
Coplen, H. L., Jr.
Cox, E. N.
Crosby, F.
Dalrymple, P. L.
Dean, M. A.
Doke, E. G.
Dwight, R. W., Jr.
Eade, F. P.
Egly, A. H.
Eichhorn, R. L.
Flebbe, P. E.
Fox, A. H.
Gaiser, F. E.
Ganier, A. F.
Gerlach, C. J.
Gerlach, J. H.
Gilbert, W. W.
Gniewosh, S. M.
Goodyear, H. R.
Grossman, F. A.
Hall, C. P.
Hammer, J. E.
Hedlund, R. A.
Hein, J. J.
Helbig, H. F.
Heller, E. W.
Heritage, E. C.
Iddles, G.
Johnson, R. E.
Jorgeson, C. M., Jr.
Kahlenberg, J. B.
Katz, J. P.
Kelley, R. M.
Kelley, R. S.
Kepner, C. L.
Kettle, J. W.
Klaiber, C. L.
Kroeger, E. J.
Kueck, H. F.
Lambert, C. W.
Langohr, R. B.
Lewis, H. E.
Louderback, P. G.
Lynch, J. H.
Mesterharm, E.
Moore, D. R.
Mull, D. F.
Naganidhi, B.
Paul, S. B.
Pearce, C. W., Jr.
Petersen, F. G.
Pierce, C. S.
Reed, T. W.
Riley, G. A.
Roth, W. L.
Russell, S.
Sasser, R. M.
Schlemmer, B. G.
Schneblin, R. N.
Sennstrom, H. R.
Setterblade, E. O.
Small, G. E.
Small, J. W., III
Smith, B. M.
Smith, W. H.
Spitler, W. L., Jr.
Sprankle, K. W.
Springman, G. F.
Steinle, D. E.
Stewart, R. R.
Stivers, F.
Strait, J.
Strang, H.
Stromm, S. M.
Tearney, J.
Tober, A. H.
Van Natta, J. W., Jr.
Vinson, F. E.
Voight, R. N.
Wahl, F. G.
Wait, D.
Wakefield, M. C.
Warner, C. F.
Warren, E. M.
Wedel, D. P.
Weldy, R. K.
Wild, J. M.
Wilson, F. B.
Winter, W. E.
Wolverton, W. B.
Wozniak, T. C.
Wright, E. K.
Wright, J. W.

Rensselaer Polytechnic Institute

Brooks, W. B.
Case, H. W., Jr.
Clark, A. R.
Clark, E. F.
Crellin, J. R., Jr.
Dimock, R. R.
Eldredge, R. M.
Estey, C. G.
Fayerweather, F. O., Jr.
Fisher, B. J.
Flemer, C. H., Jr.
Fodermaier, J. J., Jr.
French, R. E.
Gilman, R. E.
Hangarter, A. J.
Harkeleroad, I.
Harrison, R. T.
Heiter, A.
Herbert, H. D., Jr.
Jenny, J. B.
Jones, R. C.
Kinsella, W. J.
Lanno, E. C.
Lipman, J.
Marinelli, G. J.
Nolan, J. B.
Overacker, W.
Palmer, L., Jr.
Ryder, F. E.
Sawyer, A. H.
Scofield, J. M.
Scranton, G. J.
Telerico, J. A.
Wachunas, J. F.
Zimmer, A. S.

Rhode Island State College

Borden, H. K.
Danesi, M. C.
DeLuca, F.
Dobrolet, A.
Grimes, J. A.
Hartley, R.
Henry, R. W.
Holt, C. W.
Hull, R. F.
Ingram, H. W., Jr.
Mills, E. G.
Muenchinger, H. G.
Parker, H. W.
Sherman, C. R.
Warren, R. W.

Rice Institute

Baird, K. H.
Beman, J. S.
Blanton, E. B., Jr.
Boyle, E. C.
Briggs, F., Jr.
Buck, W. E.
Dwyer, T. H.
Fowler, J. McF.
Goodrich, J. D.
Greenwood, M. H.
Henderson, J. L.
James, P. H.
John, J. S.
Keating, E. W.
Liljestrand, W. E.
Minto, W. M.
Moore, S. C.
Morgan, B. L.
Morris, W. V.
Wallace, J.
Wissinger, J. E.
Wolfram, L. F.
Wright, M. C.
Young, H. B., Jr.

Rose Polytechnic Institute

Blount, F. E.
Buis, K. L.
Cantwell, C. E.
Cromwell, C. E.
Dennis, R. E.
Eckerman, E. H.
Foley, A. B.
Giffel, P. E.
Greenland, J. A., Jr.
Hunter, J. B.
Pearce, R. E.
Prewett, R. D.
Reed, T. G.
Romeiser, A. H.
Scharenberg, M. B.
Sonnefield, J. E.
Stanfield, M. L.
Stineman, J. B.
Weinbrecht, J. F.
White, R. W.
Whitesell, J. E.
Zinngrabe, C. J.

Rutgers University

Baldwin, S. O.
Burns, R.
Campbell, D. J.
Chapman, R. M.
Clapper H. W.
Curtiss, W. L.
Dey, C. L.
Erhart, F. C.
Gardner, W. A.
Jackson, R. M.
Lazansky, B. J.
Mehrhof, K. C.
Meseroll, V. F.
Newton, N. B.
Silverman, L.
Straus, R. N.

University of Santa Clara

Acurso, L. A.
Adams, W. J., Jr.
Arata, G. V.
Arismendi, C. A.
Booth, F., Jr.
Bressani, R.
Dieudonne, R. J.
Donovan, M. D.
Garlinger, D. T.
Garrett, J. E.
Gomes, F. P.
Shay, E.
Snyder, H.
Sylva, J. J.
Whitfield, M. P.
Wolff, W. A.

South Dakota State College

Aaron, P.
Barber, G. E.
Bard, R.
Bentson, R. J.
Callihan, H. W.
Cone, C. B.
Coxe, K. E.
Eliason, W. B.
Felty, D. L.
Foster, C.
Gordon, J. L.
Graves, H. V.
Hardy, H. S.
Hardy, J. A.
Herbert, R. M.
Hokanson, M. LeC.
Kantowski, F.
Lane, C. W.
Larsen, L. W.
Lyngstad, A. E.
Meeker, L. G.
Pilgram, W.
Plamann, J. A., Jr.
Reeve, J. E., Jr.
Robinson, J. C.
Roda, V. A.
St. John, R.
Stoner, J. T. A.
Vick, M. R.
Welsh, C.

University of Southern California

Ballard, L. W.
Bötticher, W. K.
Cater, B.
Chogyoji, K.
Esselman, R. B.
Foster, J. P.
Keenan, R. B.
Long, F. A.
Montgomery, J. H.
Morkovin, D.
Phelps, B. L.
Renn, J. A.
Ryder, J. H.
Salomonson, E.
Tolkmitt, R. G.
Walker, C. W.
Wheater, H. W.
White, F.
Yoshitani, B. M.

Southern Methodist University

Atkinson, P.
Blackburn, L. E.
Cheney, R. E.
Fairley, G. G.
Harris, R. M.
Henke, W.
Hestand, R. S.
Hinckley, F. B.
Holland, R.
Hord, R. N.
Howell, R. L.
Keagy, J.
Kilgore, R. B., Jr.
Lacy, J. W.
McKinney, H. H.
Miller, R. E.
Mitchell, R. F.
Mogle, W. S., Jr.
Moore, M. L.
Nichols, T.
Orrick, S.
Shimer, J. M., Jr.
Shook, S.
Smith, C.
Wheeler, C. J., Jr.
Winton, V.
Wisenbaker, J.

Stanford University

Baldo, L.
Brewster, J.
Carah, A. J.
Crispin, J. H.
Gallagher, E.
Hoblit, F. M., Jr.
Hooker, D. S.
Hopper, F. A., Jr.
Isham, H. L.
Kehke, A. E.
Krupp, R. F.
Lindsay, F. A.
Macomber, T. W.
Morey, R. H.
Munton, H. B.
Palmer, A. L.
Park, J. W.
Powell, W. B.
Ross, O. C., Jr.
Schlage, E. L.
Seaman, F. E.
Spennetta, P. H.
Studley, C. K., Jr.
Talmage, R. H.
Topham, E.
Vincenti, W.
Weaver, S. E., Jr.
Wickett, W. A.

Stevens Institute of Technology

Anderson, J.
Arons, A. B.
Bauer, J. L., Jr.
Bernstein, A.
Braxton, J. S.
Buchanan, R. L.
Budell, W.
Chownes, W. H. P.
Dickinson, H. H.
Downham, A. F.
Edwards, R.
Ehrman, B., Jr.
Fiedler, E. F.
Florea, H. R.
Forrest, H. D.
Grahn, R. V.
Grossenbacher, E., Jr.
Guggenheim, S.
Haag, H. C.
Hague, R. Z.
Hahn, P. R. T.
Halvorsen, R. A.
Heller H. P.
Hipp, G. W.
Horenburger, R. A.
Hornstein, A. D.
Howes, B. B.
Hubeny, F. G.
Hughes, T. J.
Hunt, R. G.
Jerkovich, M.
Junge, W. E.
Kamlookhine, I.
Kohanow, N.
Lamont, C.
Lewis, J. H.
MacLean, G., Jr.
Mainka, A. P.
Masi, D. M.
Mathez, E. C.
Miller, R. C., Jr.
Neuhoff, J.
Novick, D.
Roberts, F. K.
Rogers, J. G.
Rudiger, B. W.
Scelba, A. J.
Scott, T.
Semmig, A. D.
Slobey, R. J.
Spano, J. F.
Stehman, F. G.
Sturken, R. C.
Toppin, F. V., Jr.
Tyson, T.
Walsh, J. P.
Weber, T.
Weller, A. C.
Widness, J. E.
Wielkopolski, E.
Willenborg, O. H.
Wolff, E. K.

Swarthmore College

Beck, J. N.
Boyer, V. S.
Burt, O.
Coffin, L. F., Jr.
[illegible], L. J.
Harrison, W. T.
Hendricks, O. G.
Hickok, J. E.
Hoadley, H. H.
Holderle, F. S.
Pittinger, A. L.
Taggart, C. I.
Valentine, G. W.
Walker, R. B.
Warner, R. D.

Syracuse University

Baker, M. J.
Barnes, D. H., Jr.
Blair, R. W.
Bogdanoff, J.
Bouton, E. L.
Boyle, W. F., Jr.
Burrell, D. L.
Center, K. W.
Chamberlain, W. E.
Davenport, K. R.
Fassler, E. A.
Frayer, L. W.
Goodman, H. E.
Hale, J.
Hartson, J. F.
Helmer, R. S.
King, G. J.
Leprohon, L. C., Jr.
Schug, D. F.
Sitterly, C.
Stumpf, R. C.
Wadsworth, A. J.
Ware, G. A.
Weeks, F. D.

University of Tennessee

Anderson, C. H.
Brasfield, J. E.
Dix, R., Jr.
Kivitt, D. F.
Lane, B. W.
Lingo, L.
Morgan, J. E.
Ritter, R. G.
Russell, R. McC., Jr.
Studley, R. C.
Swann, L. H.
Taylor, V. C.
Underwood, F. W.
Warren, M., Jr.
Wright, I. W.

Texas Agricultural and Mechanical College

Berg, L. E.
Birt, B. B.
Bowie, R. G.
Bowie, T. A.
Boyle, R. B., Jr.
Bradshaw, T. E.
Dodge, J. H.
Donahue, D. P.
Dudley, A. C.
Emery, D. M.
Friedline, J. W.
Grant, R. G.
Grimmer, R. A., Jr.
Harris, W. W.
Heye, O.
Huffhines, G. H.
Hughes, J. C.
Jaynes, J.
Lake, S. T., Jr.
Luetcke, C. J., Jr.
Luke, E. D.
Morriss, J. C., Jr.
Mozisek, A. R.
Perritte, H. H.
Poole, D.
Reinarz, A. R.
Rose, H. E.
San Miguel, A. A.
Smith, W. C.
Stevenson, J. M.
Stradinger, J., Jr.
Thompson, Y. E.
Turner, T. T.
Underwood, C. W.
Vollentine, J. W., Jr.
Weaver, R. S., Jr.
White, R. E.
Yardley, J. T., Jr.

Texas Technological College

Ayers, H. J.
Barry, J. C.
Beauchamp, H.
Buchenau, H.
Coneway, R. P., Jr.
Cooper, A. R.
Doucette, B.
Houston, R. E.
Howell, C. M.
Jacobsen, B. O.
Jones, W. E.
Kelley, J.
Meredith, H.
Mueller, L.
[illegible], L., Jr.
[illegible], M. B.
[illegible], J. T., Jr.
[illegible], J.
[illegible], B.
[illegible], E., Jr.
[illegible], M. E.
[illegible], B.

University of Texas

Adams, F. V.
Besserer, C. W.
Biggerstaff, N. B.
Bodemüller, R.
Burgess, R. M.
Burton, V. W.
Cohen, A. J.
Crockett, H. B.
[illegible], P. B.
[illegible], E. M.
Evans, S. W.
Foster, J. V.
Francis, W. C., Jr.
Fuller, R. L.
[illegible], A.
Goerner, F. A.
Griffis, W. E. C.
Halton, J. G.
Hardgrave, R. L.
Hashagen, R. L.
Hewitt, R. T.
Hight, C. J.
Hoffmann, E. H.
Howison, R.
Hudson, E.
Ingram, B. B.
Ivey, W. L.
Kainer, J. E.
Knight, W. H.
Lee, R. J.
Ligon, J. R.
Luedecke, W. H.
Mayer, J.
McBride, R. J., Jr.
McCrocklin, A. J., Jr.
[illegible], J. E.
Moore, B. P.
Morris, G. C.
Morris, J. T.
[illegible], E. H.
Nelson, H. M.
Newell, J. H.
Nolley, J. P.
Perkins, E. S.
Potter, J. W.
Pratt, O. L.
Pugsley, C. S., Jr.
Ramsey, J. W.
Ramsey, T. I.
Rather, R. L.
Ross, J. E.
Samway, J.
Schmidt, C. D.
Scott, J. M.
Selkirk, J. W.
Sheaffer, W. H.
[illegible], C. F.
[illegible], L., Jr.
[illegible], C. P.
[illegible]
[illegible], J. W.
[illegible], H. G., Jr.
[illegible]
[illegible]aub, S.
Woodruff, W. F.
Wright, L. T., Jr.

University of Toronto

Allan, M. B.
Bates, R. E.
Beynon, C. E.
Boyd, R. N.
Boyd, W.
Burgess, J. A.
Carmichael, J. A. N.
Carriere, M. F.
Chernovsky, B.
Clarkson, A. G.
Cohen, L.
DeMaio, A.
Devereaux, W. A.
Dick, H. D.
Dilworth, P. B.
Dugit, J.
Elms, G. H.
Ernst, C. A.
Fergus, A. W.
Foreman, A. S.
Foster, L. C.
Fry, J. W.
Greason, J.
Hamer, I. M.
Hemphill, J. L.
Henry, D. A.
Hewson, A. C.
[illegible], G.
[illegible], J. H.
[illegible], P. K.
Lumbers, C. G.
Maher, G. T.
Malcolm, D. R. V.
Margesson, R. D.
McEwen, F. W.
Minaker, H. L.
Otter, G. E.
Parrish, V. M.
Sheridan, L. B.
Smith, I. W.
Steele, D.
Stott, J. E.
Trusler, W. R.
Turner, E. S.
Woods, W. B.
Wooldridge, F. A.

Tufts College

Bennett, G. S.
Blanchard, C. A., Jr.
Bradbury, D.
Bryne, G. H.
Cahill, F. J.
Canavan, J. E.
Dale, G. E.
Doran, J. W., Jr.
Flaws, D. B.
Fleming, W. A.
Flint, E. F., Jr.
Foisy, J. E.
Gallagher, T. V.
Hirsch, J.
Hunt, R. W.
Lillis, J. C., Jr.
McCulloch, A. D.
Moberg, E. S.
Noble, E.
O'Toole, J. M.
Parman, W. A.
Pote, L. W.
Rendall, J. B., Jr.
Rodofsky, R. E.
Shaw, B. W.
Towne, E. W.
Wengen, G. E.
Willoughby, R. J.

Tulane University

Blakeslee, H. W.
Bohne, L. H.
Bopp, J. M.
Bouche, S.
Brown, H. I.
Cazenave, E., Jr.
Cosgrove, B. D.
deGruy, W. V.
DeMajo, J. J. R.
Englebardt, G. W.
Fortier, J. L.
Frischhertz, N. F.
Graugnard, J. B. C.
Hall, J. E., Jr.
[illegible], D. E.
[illegible], Jr.
[illegible], E.
[illegible], M. J., Jr.
Lockett, R. P., Jr.
Markel, N. W.

Menefee, G. H.
Morehiser, J. E., Jr.
Moses, W. G.
Nelson, C. W.
Paterson, A. B., Jr.
Pick, M. E.
Robins, L.
Roehm, P. R.
Rombach, J. R., Jr.
Soniat, E. J.
Stern, F. B., Jr.
Weidig, I. C.

University of Utah

Abbott, F. M.
Arlt, W. P.
Berry, J. G.
Dansie, G. W., Jr.
Eatough, G. W.
Erskine, L. A.
Harris, F. A.
Hatch, B. D.
Holmes, R. H.
Huber, P. O.
Hulmes, A. W., Jr.
Hutchinson, J. H.
Jarvis, D. H.
Mattson, H.
Miles, K. F.
Nelden, W. A.
Nelson, L.
Neuhart, S.
Quist, C. L.
Richards, R. L.
Sentker, L.
Snow, R. T.
Wilde, O. C.
Wilstead, H. D.

Vanderbilt University

Brengelman, G. D.
Buchanan, H. J.
Clay, W. H.
Comer, W. H.
Elliott, F. F.
Finley, G.
Hughes, E. C.
Jackson, W. W., Jr.
Jones, D.
Martin, W. G., III
McGinness, J. H.
Poste, E. A.
Travis, J. W.
Van Dyke, R.
Wallace, J. E.
Williams, H.
Witherspoon, J.
Woods, F. B.

University of Vermont

Abbott, N. M.
Canary, F. H
Converse, F. M.
Gear, F. T.
Hall, A. S., Jr.
Harriman, B. W.
Householder, E. S.
Leekoff, D.
Lyman, E., Jr.
Manley, R. F.
Renfrew, C. A.
Snow, R. M.
Truax, F. H.
Wheeler, W. A., Jr.
Whipple, E. R.
Wiseman, F. K.

Villanova College

Callan, J. P.
Christoph, J. B.
Christoph, O. K.
Cotter, N. J.
Delaney, J. J.
Fanning, A. E.
Melian, R.
Rappleyea, F. A.
Ritti, E. A.
Wolff, E. A.

Virginia Polytechnic Institute

Angell, P. T.
Barksdale, W. S., Jr.
Barry, N. E.
Benson, F. R., Jr.
Carmel, M. M.
Carpenter, M. S.
Chambers, D. R., Jr.
Davis, J. H.
Gibbs, R. G.
Gooden, M. P.
Graham, J. M., Jr.
Green, F. C.
Haws, R. S.
Hollingworth, T. A.
Hutchison, G. M.
Jones, G. T.
Kerfoot, F. W.
Kuhn, B. D., Jr.
Marean, N. H.
Mongle, J. H.
Pais, W. J.
Pittman, C. P.
Richards, C. D., Jr.
Sanders, J. C.
Sanders, N. D.
Smythe, B. T.
Thayer, P. G.
Ware, J. F., Jr.

University of Virginia

Bild, C. F.
Ehrich, L. S., Jr.
March, P. G., III

Washington State College

Allen, J. D.
Anderson, R.
Baila, H. L.
Behrman, W. M.
Brunelle, H. E., Jr.
Cammon, R. B.
Cartwright, W. J.
Davidson, A. J.
Davidson, G. E.
Hanson, E. R.
Hemingway, H.
Hoffman, J. E.
Karcher, J. E.
Larson, L.
Marshall, C. W.
Melhart, A.
Neill, T. C.
Plotner, N. E.
Shirk, I. A.
Siverson, M. A.
Slate, H. B.
Stoltz, F. W.
Swann, J. P.
Wetzel, J. A.
Youngs, A. B.
Zier, G. F.
Zier, H. G.

Washington University

Beare, G. K.
Belches, E. B.
Brooker, H. F.
Ecoff, R. A., Jr.
Elliott, C. R.
Evers, E. P., Jr.
Funk, W., Jr.
Geselbracht, W.
Haas, O. J.
Hail, E.
Hassemer, D
Hexter, J. P.
Miller, O. C.
Monning, E. G., Jr.
Moore, J. R.
Morgan, W.
Newton, R. E.
Noell, R. W. H.
Odell, W. R. C.
Oldenderph, O.
O'Neill, T. J.
Rasch, LeR. L. S.
Rosebrough, J. D.
Sauer, L. E.
Schlatter, R. P.
Schmidt, R. B.
Schreiber, W. A.
Schroeter, P.
Seifert, R. F.
Shaner, M. S.
Shelton, H. J.
Siegfried, S. M.
Spitzfaden, C., Jr.
Still, P.
Tanaka, J. K.
Titus, J. H., Jr.
Toedtman, J. A.
Trowbridge, L. E., Jr.
Wischmeyer, W. F.

University of Washington

Bruun, F. A.
Burgher, M. G.
Field, W. P.
Foster, R. G.
Fryer, E. H.
Hage, S. D.
Henderson, R. R.
Hitchcock, R. C.
Hite, M. W.
Hodder, E. S.
Jack, T. M.
Johnson, W.
Jones, R. K.
Lambrecht, J. L.
Lindsay, W. H.
Lundstrom, G. O.
Lysons, H. H.
Martinson, G. C.
Miller, R. S.
Olds, R. H.
Philbrick, W.
Priebe, O. W.
Prisadsky, O. A.
Pugnetti, L. J.
Reed, C. G.
Scroggs, A. M.
Smith, M. A.
Soderlind, R. N.
Walter, D. E.

West Virginia University

Abbott, R. H.
Amato, E. J.
Clower, M. G.
Diamond, W. F.
Fisher, A. W.
Gorrell, C. W.
Hornbeck, D. E.
Huber, G. J., Jr.
Hudelson, W. H.
Irons, C. R.
Kyle, G. M.
Park, B. L.
Porter, J. E.
Ritchie, A. H.
Ruck, G.
Swing, C. E.
Townsend, J. A.
Turoff, N. L.

University of Wisconsin

Adams, C. W.
Amery, G. R.
Andree, P., Jr.
Arens, H. C.
Barlow, F. J.
Baver, E. E.
Berry, E. J.
Blatecky, J. A.
Boettcher, R. A.
Brindley, R. B.
Broberg, L. E.
Buchberger, L. J.
Damrow, E. E.
Dansfield, R.
DeGroot, E. N.
Dettmann, C. E.
Dobrogowski, D. T.
Evans, R. H.
Fredrickson, M. D.
Freund, F. C.
Garcia, O. F.
Goetz, M.
Gother, W. F.
Grether, F.
Gunther, F. J.
Halberg, R. W.
Henneman, C. O.
Horneck, C.
Ibisch, F. O.
Johnson, F. M.
Kirtland, E. M.
Kommers, W. J.
Krane, S. J.
Lagergren, J. M.
Lamb, D. H.
Langley, G. F.
Leviton, H.
Lindergren, E. P.
Lippert, R. J.
Losse, R.
Marshall, J. M.
Marshall, L. S.
Melms, C. B.
Mitchell, W. A.
Munro, H. L.
Myers, J. R.
Orthey, F.
Oscar, G. R.
Pfeffer, D. P.
Pike, K. R.
Rau, F.
Runckel, J. F.
Sawyer, C. L.
Schaal, R. E.
Schlintz, H. H.
Schmidt, W. G.
Senft, J. H.
Severson, P. T.
Sharp, R. A.
Sohns, C. B.
Sorenson, W. H.
Stanley, R. U.
Stieg, B.
Stiegler, E. A.
Swifka, E. J.
Thiele, C. H.
Thom, A. J.
Vander Wall, C.
Volkmann, H. W.
Wenman, W. A.
Wright, H. W.
Wright, R. E.
Yugo, J. F.

Worcester Polytechnic Institute

Abbott, F. L., Jr.
Abel, W. L.
Allen, L. T.
Amidon, C. H., Jr.
Anderson, E. S.
Babcock, R. A.
Balaseuich, J. J.
Bergstrom, P. H.
Blanchard, H. J.
Boyd, J. F.
Burg, F. J.
Casey, J. R.
Chadwick, C. D.
Chesworth, P.
Clark, D. B.
Cox, H. N., Jr.
Crabtree, E. B.
Delany, J. V.
Deschere, A. R.
Dexter, R. H.
Edmands, R. S.
Elliott, R. M.
Farrar, R. O.
Fenner, E. M.
Fick, O. A., Jr.
Field, R. H.
Glazier, P. R.
Gustafson, E. E.
Hammond, C. D., Jr.
Higginson, J.
Holbrook, J. A.
Hollick, J. G.
Holt, W. H.
Houser, D. E.
Hunt, D. H.
Jewett, G. W.
Johnson, A. H.
Karakoosh, R.
Kelsey, R. A.
Lloyd, R. S.
Marshall, M. E.
Meany, P. E.
Merrill, D. K.
Moore, E. W.
Moore, J. F.
Muller, R. J.
Nygaard, W. O.
Olson, C. K.
O'Neil, T. E.
Otto, C. S.
Pierce, C. P.
Pyne, F. S.
Raphael, F. S.
Rafuse, M. T.
Richards, W. G.
Rivinius, G. A., Jr.
Rollins, F. W.
Sawtell, E. A.
Smith, J. M.
Strandberg, F. E.
Stratton, D. D.
Stromberg, V. O.
Sutcliffe, J. W.
Swartwout, J. F., Jr.
Taylor, F., Jr.
Thompson, G. L.
Tolman, R. H.
Turner, E. E.
Vickery, E. R., Jr.
Webster, F. N.
West, R. F.
Whitcomb, M. B.
Wilson, B. H.
Woodward, D. W.

University of Wyoming

Arkoosh, F. G.
Bjorn, L. C.
Gonder, W. W.
Greever, W. H.
Guffey, R. L.
Hieber, E. E.
Himmelreich, J. W.
Johnson, H. I.
Lipton, S.
Moss, J.
Murray, M. D.
Newcomb, C. E.
Niederjohn, R. K.
Occhipinti, S. D.
Sudduth, J. S.

Yale University

Bascom, J. H.
Board, S. S., Jr.
Cochran, A. R., Jr.
Dixon, A. B.
Duer, R. K.
Edgar, C. S.
Foote, W. R.
Fowler, C. R.
Fowler, F. H., Jr.
Gray, W.
Harrington, G. N.
Higgins, R. D. L.
Hunter, F. W.
Hutchinson, B. L., Jr.
Irwin, D. B.
Kennedy, W. S.
Knowles, H. C., Jr.
Lathbury, B. K.
Leilich, G. M.
Lorenzini, R. A.
McDonald, J.
Mettler, G. H.
Murphy, J. E., Jr.
Nevmunz, G. M.
O'Gorman, W. P.
Packer, J. B., Jr.
Palmer, W. B.
Reeder, R. T.
Robinson, H. W.
Root, F. V.
Roseman, R. J.
Scott, E. H.
Shepard, B. M.
Wargo, F. E.
Wells, T. M.
Whitmyre, G. R.
Wiggin, F. A.
Wilson, T. F.
Zimmerman, T. M.

The Prevention of Failures of Surface-Condenser Tubes

By R. E. DILLON,[1] G. C. EATON,[2] BOSTON, MASS., and H. PETERS,[3] CAMBRIDGE, MASS.

This paper describes the developments in the prevention of failures of surface-condenser tubes in the steam-electric generating stations of The Edison Electric Illuminating Company of Boston. The authors apply the latest theories of destructive cavitation to show that the inlet-end wastage of tubes in a single-pass condenser is the result of vortices in the inlet water box. These vortices result in destructive cavitation which starts when the water pressure at a point approaches the pressure corresponding to the water temperature, and the cavities in the water are filled with vapor. When the existence condition for the vapor disappears through increase of pressure, the vapor bubbles condense and very high impacts on adjacent surfaces result. Tiny particles are broken from the surface by repeated impacts, making larger and larger pits, and eventually holes through the tube are produced. Guide vanes installed in the inlet water box of the condenser have effectively prevented the vortices from forming.

SINCE the early years of this century, the steam-electric generating stations of The Edison Electric Illuminating Company of Boston have been the testing ground for surface condensers. With the full knowledge that the surface condenser can be the source of a major yet preventable loss of power-plant efficiency, the engineers of this company have been indefatigable in their efforts to develop and apply practical ways and means of keeping surface-condenser tubes clean and to increase the economic life of the condenser tubes themselves. It is with the second of these endeavors concerning surface condensers that this paper deals.

Some 25 years ago, in cooperation with the condenser-tube manufacturer who developed the process, tubes of Admiralty metal made by the cup-drawn method were tried out in the surface condensers serving the vertical turbines in the early section of the L Street Station in South Boston. Steam at 200 lb per sq in., and 500 F operate these turbines. The results of the early experiments and developments were very gratifying. Dezincification and consequent tube failures sharply decreased. A large portion of the Admiralty tubes installed at that time are still in service due to developments which will be discussed in this paper.

With the reduction of dezincification, the phenomenon of inlet-end wastage of condenser tubes was made more pronounced. It was noted that this wastage was concentrated within the first few inches. Since the tubes were packed with corset lacing and ferrules, the use of longer or extended ferrules was tried in the hope of confining the wastage to the replaceable ferrule. Moderate success was achieved by this method.

The replacement of extended ferrules, while much cheaper than tube renewal, was nevertheless expensive. The idea of lining the inlet end of the tubes with a bushing which could be easily inserted and readily replaced was conceived and developed (see Fig. 1). An effort was made to conform the inside surface of the bushing to the shape of the vena contracta in order to remove at this point the turbulence and high vacua with consequent air liberation from the circulating water. This turbulence and air liberation were at that time blamed for the inlet-end wastage of the tubes.

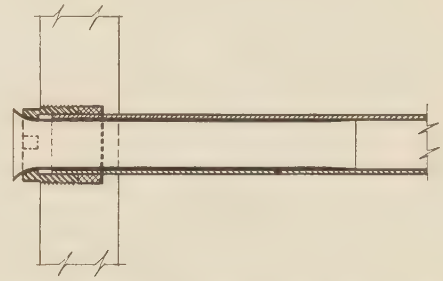


Fig. 1 Bushing Inserted in Tube Packed With Corset Lacing, Fiber Washer, and Screwed Ferrule

The inlet-end bushing was a pronounced success and a major step in the prolongation of tube life. There was but one detrimental effect of the use of the bushings upon the condenser tubes themselves. The tapered or downstream end of the bushing (see Fig. 1) cannot be made infinitely sharp or to fit exactly the inner surface of the tube. As the result of these practical limitations, there is an irregularity or shoulder in the combined inner surface of bushing and tube, *after* which minor tube wastage usually occurs. This effect upon the tube has been minimized by installing subsequent bushings of increased length to cover the slightly wasted portion of the tube. The bushings have invariably required replacement before the tube wastage at this point has become serious.

[1] Superintendent of the Generating Department, The Edison Electric Illuminating Company of Boston. Mr. Dillon was graduated from Massachusetts Institute of Technology in 1910. After six months with the North Packing and Provision Company, he entered the employ of the Edison Electric Illuminating Company of Boston and before promotion to his present position was successively head of the Steam and Chemical Division of the Standardizing and Testing Department, technical engineer, and assistant superintendent in the department he now heads.

[2] Head, Mechanical Technical Engineering Division, Generating Department, The Edison Electric Illuminating Company of Boston, Jun. A.S.M.E. Mr. Eaton was graduated from Harvard College in 1923, and from the Harvard Engineering School in 1925. Since 1925 he has been employed as a mechanical engineer in the division he now heads.

[3] Assistant Professor of Aeronautical Engineering, Massachusetts Institute of Technology. Dr. Peters received his Dipl. Eng. degree from the Technische Hochschule of Darmstadt, in 1925, and his Dr. Eng. degree from the Technische Hochschule of Munich, in 1930. For five years he was assistant at the Kaiser Wilhelm Institut für Stromungsforschung. In 1931 he became Research Associate at the Massachusetts Institute of Technology, where in 1935 he was advanced to his present position.

Contributed by the Power Division for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until June 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

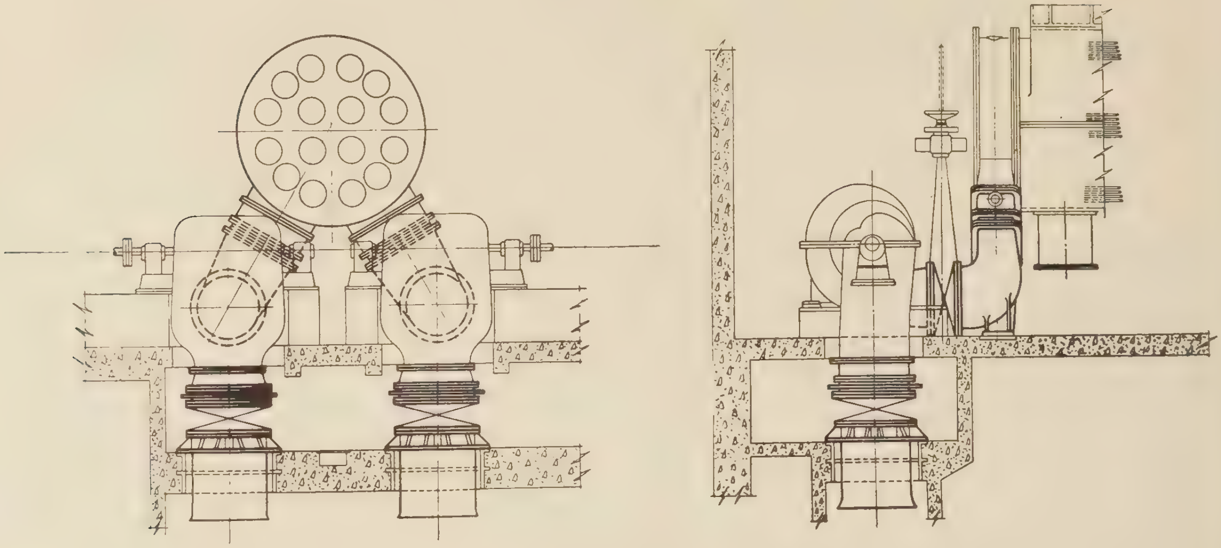


Fig. 2 Single-Pass Condenser With Pumps and Connected Inlet Piping as Installed at the Edgar Station

The problem of tube cleaning when bushings are installed has been successfully solved by the use of bristle brushes six to eight tube diameters long. These brushes are inserted at the inlet end of the tube and "shot" through the tubes by a "gun" admitting a turbulent mixture of water and compressed air behind the brush.

Single-Pass Condenser

The first single-pass condenser to be installed in a Boston Edison station was placed in service in 1927, and soon after it was equipped with bushings. Until this installation, only two-pass and four-pass condensers were in use at the L Street and Edgar Stations. The life of the tubes in these multipass condensers was entirely satisfactory and has continued to be so after the installation of the bushings previously described. The new single-pass condenser required complete retubing in 1932 after but five years of service. The necessity of this retubing had until the last two years been attributed very largely to the unsuccessful use of an inferior type of chlorinating equipment for treating the circulating water to inhibit slime formation in the tubes. Subsequent experience with the second set of tubes has shown that undue weight was given to the effect of improperly used chlorine gas on the first set of tubes, although there is no question but that its use materially hastened tube replacement.

Search for Methods of Eliminating Air Liberation

The very early failure of a considerable number of the second set of tubes near their inlet ends but beyond the downstream ends of the bushings caused the engineers to renew their search for causes of tube failure.

In order to observe and to understand more clearly the conditions existent on the water side of the condenser, observation windows were installed in four access doors of the inlet water box together with adequate illumination. Two of these windows were located just above the horizontal center line of the water box and the other two near its top. Observations through these windows showed that in the upper third of the water box there was a highly turbulent mixture of from very large to very small air bubbles and water. Also in this upper third of the water box, for long and for short periods of time and sometimes almost continuously, long ribbons of air surrounded by a spinning mass of air-bubble-and-water mixture would run from the mid-portion of the water box to the tubes.

Fig. 3 Tubes Removed From Single-Pass Condenser During Four Years of Operation

Attempts to reduce the air liberation had of necessity to be confined to the reduction of minor turbulence in the water box and connected inlet piping, pumps, and intake tunnel. Irregularities in the inside surfaces of these passages were removed or smoothed wherever practicable, the pump impellers and casings were checked for exact alignment, and air leakage at the packings was minimized. The inlet tunnel was vented to insure that no accumulation of air would form near its roof to be drawn at intervals into the pump suction lines. Vertical baffles of various lengths attached to the braces in both inlet and discharge water boxes were tried in an attempt to reduce the surging that was also observed. Two circulating-water pumps were used instead of the usual one to reduce velocities with the accompanying turbulence and air elimination.

These efforts brought little or no improvement in the observed conditions, and tubes failed in increasing numbers. Thus, it

became increasingly clear to the engineers that with the existing arrangement of water box, connecting piping, and pumps shown in Fig. 2, no small changes would reduce the air liberation then believed to be the sole cause of the tube failures. Causes other than air liberation were then looked for in the hope of solving the acute problem without redesigning the existing equipment. In this connection the cavitation experiments at the Massachusetts Institute of Technology were investigated.[4]

Cavitation and Corrosion

A study of the location of the tube failures had already indicated that there were two areas where the percentage of tube failures was relatively much higher than in the remainder of the tube bank. One of these was in the upper-left lobe and the other slightly to the right and below the center of the tube sheet, as viewed from the entrance end of the tubes. These locations are indicated in Fig. 3. Also the damage to the individual tubes was found to occur at the end of the bushings and extending a short distance downstream. The bellmouth entrances to the bushings showed a general thinning nearly equal all over the tube bank, while the divergent part was worn most in the areas of greatest tube failure. The localization of the tube and bushing damage is most reasonably explained as the result of destructive cavitation followed by corrosion. To produce destructive cavitation, the water pressure at a point must approach the vapor pressure corresponding to the water temperature, so that cavities in the water

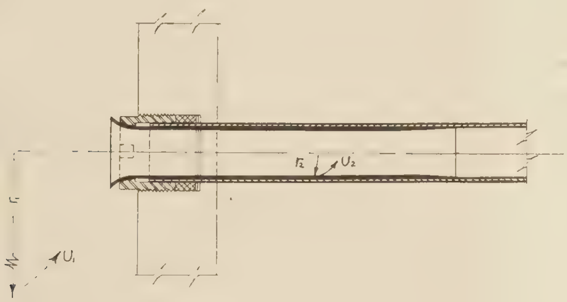


Fig. 4 Water-Box and Tube Velocities for Rotating Flow

are filled largely with vapor. If the existence condition for the vapor disappears through increase of pressure, the vapor will condense or collapse, and an exceedingly high pressure will occur due to the impact of the water filling the vapor space from all sides. Destructive cavitation on any surface will break tiny particles from that surface thus making pits. These pits are well adapted for the accumulation of oxides and salts beneath which a rapid attack may proceed, furthered by the ready supply of oxygen from the liberated air. If this hypothesis, which is readily applicable to a condenser tube, were correct, it would then be desirable to prove the actual possibility of destructive cavitation in the single-pass condenser.

Moody and Sorenson[5] have very definitely proved that cavitation will occur when

$$v_2 = \sqrt{[2g(h_1 - h_2)]} \quad \ldots\ldots\ldots\ldots [1]$$

where v_2 = axial velocity, fps; g = acceleration due gravity; h_1 = static pressure, ft of water; and h_2 = absolute vapor pressure corresponding to the water temperature, ft of water.

If, in a top tube of the single-pass condenser at low tide, h_1 = 12 ft, g = 32 fps per sec, and h_2 = 0.7 ft at 70 F, then the minimum axial velocity v_2 for cavitation to occur will be 26.9 fps. Study of the hydraulics of the condenser show such velocities

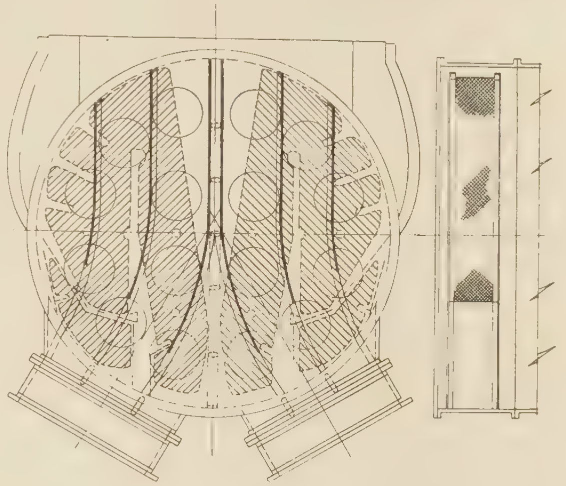


Fig. 5 Guide Vanes Installed in the Inlet Water Box of the Single-Pass Condenser at the Edgar Station

axial to the tubes to be impossible. However, cavitation can easily occur if the water flow in the water box has *tangential* velocity components. Actual observation of the flow had shown tangential-velocity components of appreciable magnitude. The ribbons of air previously referred to were the cores of the vortices and indicated the low pressures existent to release the air.

Referring to Fig. 4 which shows the relative positions of the rotating flow in the water box, a bushing, and tube, the tangential velocities and the radii bear the relation

$$u_1 r_1 = u_2 r_2 \quad \ldots\ldots\ldots\ldots [2]$$

and Bernoulli's theorem gives the pressure-velocity relation

$$h_1 + \frac{u_1^2}{2g} = h_2 + \frac{u_2^2}{2g} + \frac{v_2^2}{2g} \quad \ldots\ldots\ldots\ldots [3]$$

where u_1 = tangential velocity at r_1 of the free vortex in the water box, fps; u_2 = tangential velocity at r_2 of the free vortex in the bushing, fps; r_1 = radius of the vortex in the water box, ft; and r_2 = sectional radius of the bushing, ft.

Solving Equations [2] and [3] for u_1 gives

$$u_1 = \sqrt{\left[\frac{\left(h_1 - h_2 - \frac{v_2^2}{2g}\right) 2g}{\left(\frac{r_1}{r_2}\right)^2 - 1}\right]} \quad \ldots\ldots\ldots\ldots [4]$$

For the hydraulic conditions existent in the condenser, u_1 at a radius of 1 ft would have to be of the order of 0.5 to 1.0 fps to produce cavitation,[6] i.e., yield h_2 equal to the vapor pressure. Such tangential velocities have been observed repeatedly. Cavitation, therefore, exists and appears in the divergent part of the bushings, but the collapse occurs downstream therefrom in the

[4] "Cavitation Research," by J. C. Hunsaker, *Mechanical Engineering*, vol. 57, April, 1935, pp. 211–216.

"Progress Report on Cavitation Research at Massachusetts Institute of Technology," by J. C. Hunsaker, Trans. A.S.M.E., vol. 57, October, 1935, paper HYD-57-11, pp. 423–424.

[5] "Progress in Cavitation Research at Princeton University," by Lewis F. Moody and Alfred E. Sorenson, Trans. A.S.M.E., vol. 57, October, 1935, paper HYD-57-12, pp. 425–428.

[6] Equation [4] reverts directly to Equation [1] when the tangential velocity u_1 of the vortex in the water box is zero, then $[h_1 - h_2 - (v_2^2/2g)] = 0$. Solving for v_2 gives $v_2 = \sqrt{[2g(h_1 - h_2)]}$, that is, Equation [1].

bushings and tubes. The relatively low pressure level and the resultant release of air have a damping effect on the action and prevent the pressure from reaching as high a value in the moment of collapse of the vapor cavities as would otherwise be possible. The cavitation effect, however, will be sufficiently strong to destroy possible protective films. The liberated air, then, will accelerate the oxidation, especially when compressed in the moment of cavity collapse.

The Prevention of Cavitation

From the foregoing theoretical analysis, the next step was to prevent the formation of the vortices with their damaging tangential-velocity components in the condenser itself and the resulting cavitation and tube failures. The rotation of the water to form these vortices was effectively stopped by running two circulating pumps at reduced speed and guiding the flow from the two entrances by vanes located as shown in Fig. 5. The vanes were made from brass angles and $^1/_4$-in. mesh, 16-Bwg Admiralty metal screen. These guide vanes have effectively eliminated the vortices without increasing the pressure drop across the condenser. The authors are confident that time will prove the effectiveness of the guide vanes in reducing tube losses.

Analysis and Tests on Hydraulic Circuits of Surface Condensers

By G. H. VAN HENGEL,[1] DETROIT, MICH.

Illustrated by actual test results, this paper deals with an analysis of hydraulic circuits of surface condensers. The losses in the tubes, condenser water boxes, and piping are treated in detail. The importance of the weir losses in the outlet box is demonstrated. Tests on condensers with and without a weir show the actual gain in hydraulic efficiency obtained without a weir. An exact method is given for the calculation of the liberated air in determining the hydraulic-circuit losses. Since the amount of air liberated governs the rate of corrosion of the tubes, this calculation is of considerable importance, especially for salt-water conditions.

THE PATH of flow followed by the cooling water in passing through the hydraulic circuit of a surface condenser is a long one. The losses due to flow of the water can be separated, for calculation, into (*a*) the canal losses, (*b*) the tube losses, and (*c*) the condenser piping and water-box losses, the latter including the outlet-box weir loss.

These losses, which will be dealt with subsequently in this study, show that the losses of the weir in the outlet box play a large rôle in the total head loss through a condenser, and that the greatest improvement in the hydraulic circuit can be made by omitting the weir.

A way of calculating the air liberated from the circulating water at any point in the system will be described, and from this the siphon loss will be deduced. The importance of this calculation is for determining the venting of the circulating-water circuit and the possibility of tube corrosion and its prevention.

The Calculation of the Losses in a Hydraulic Circuit

(*a*) *Canal Losses.* Before the circulating water serves its function of cooling in the condenser, it must be pumped from the river or storage reservoir, and to this source it must also be returned. The connection between the cooling-water source and the condenser is furnished by the canal tunnels. For the highest load, the goal should be a maximum loss of 1 ft, including the losses through the trash rack and screens. Naturally, if more than one condenser is served by the same intake and overflow canals, this loss will be somewhat larger. Economic reasons will determine how high it actually can be. The screens form most of the canal losses, and adequate attention should be given in the design to keep the velocities as low as possible through these screens. Even then they cause high losses if not cleaned frequently. They are usually clogged most in the late summer from leaves, grass, and fish, when a great quantity of water is still demanded for cooling.

Attention should be given to the fact that air liberated in the intake tunnel from swirling should have an opportunity to escape before it enters the circulator suction, instead of being allowed to go through the hydraulic circuit of the condenser. In designing concrete tunnels, sudden changes in area or sharp corners should be avoided, and overhead beams should not be put in unless in connection with a vent to skim off air.

(*b*) *Tube Losses.* Of the three losses, those through the tubes can be calculated most accurately. They consist of friction, entrance, and exit losses. The friction losses are based on the equation

$$p = \lambda \frac{L}{D} \frac{\rho u^2}{2} \qquad [1]$$

where p = pressure drop, lb per sq ft; λ = friction coefficient, dimensionless; L = length of path of flow which in this study is equal to the tube length, ft; D = inside diameter of tube, ft; u = mean velocity through the tube, or flow by volume divided by the cross-sectional area of the tube, fps; and ρ = mass density of the water, lb sec²/ft⁴. The mass density $\rho = d/g$, where d = weight density of water, lb per cu ft; and g = standard acceleration due to gravity, 32.174 ft per sec per sec.

Customarily the formula

$$h = \lambda \frac{L}{D} \frac{u^2}{2g} \qquad [2]$$

is used, where h = the head loss, ft of water; and the other terms are the same as given previously.

All values, except λ which is a function of the Reynolds number, can be directly calculated for any particular condenser.

According to the latest data of Prandtl-von Kármán (1, 2),[2] for smooth pipe and turbulent flow

$$\frac{1}{\sqrt{\lambda}} = 2 \log_{10}[(\mathrm{Re})\sqrt{\lambda}] - 0.8 \qquad [3]$$

where (Re) = Reynolds' number, and λ = a dimensionless friction coefficient. The form of the formula comes from von Kármán (2) and the constants were determined from tests made by Nikuradse (3) in 1928 and 1929. The formula is also given by Hemke in an American handbook edited by Eshbach (4). This formula is very cumbersome to use, and therefore is given in graphical form in Fig. 1.

The Reynolds number can be calculated from the formula

$$(\mathrm{Re}) = uD/\nu \qquad [4]$$

[1] Consultant, Detroit Edison Company. Mem. A.S.M.E. Mr. Van Hengel was graduated from the Technical University of Delft, The Netherlands, in 1918, with an M.E. degree. After graduation he spent three years in Holland on design and construction of industrial plants. In 1921 he came to the United States for a study trip, and for half a year visited many kinds of factories. He spent six years with the Worthington Pump & Machinery Corporation, Cincinnati, Ohio, and Harrison, N. J., on design, testing, and research of centrifugal pumps, condensers, dry-vacuum pumps, and steam air ejectors. For two and one-half years he was chief engineer of the Issoudun Aircraft Manufacturing Company, Northville, Mich., makers of all-metal amphibians. Since 1930 he has been a consultant for the Detroit Edison Company on steam condensers and auxiliaries.

Contributed by the Power Division for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until June 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

[2] Numbers in parentheses refer to Bibliography at the end of the paper.

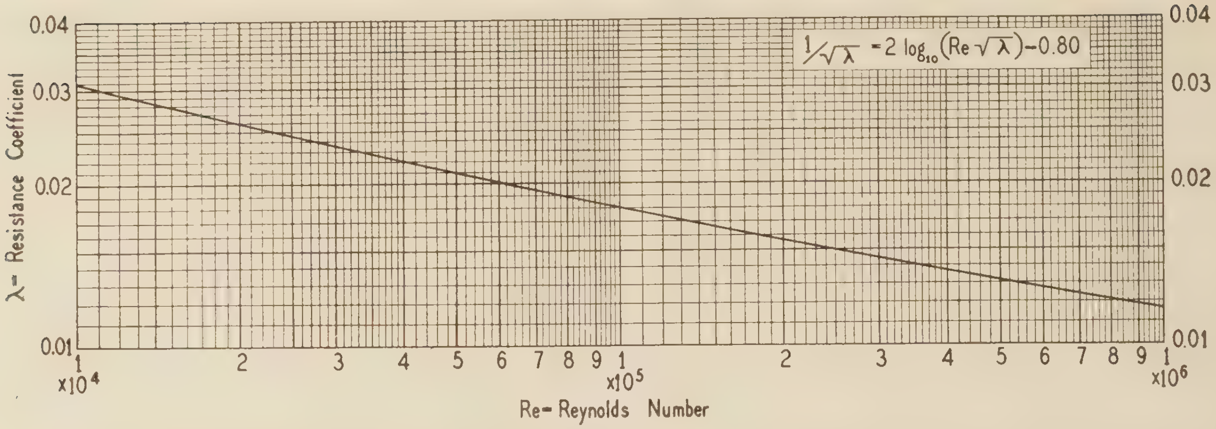


Fig. 1 Resistance Coefficient λ as a Function of the Reynolds Number for Turbulent Flow Through Smooth Pipes
(The formula represents Nikuradse's tests made with water in turbulent flow at Reynolds numbers between 3070 and 3,230,000 through pipes of inside diameters from 0.394 to 3.94 in.)

where ν = the kinematic viscosity of the water ft² per sec. The values of the kinematic viscosity in these units are given graphically in Fig. 2 for water temperatures between 32 F and 212 F. To the author's knowledge, no curve of kinematic viscosity in these units has been published before.

The inlet and outlet losses can easily be expressed as a function of the velocity head $u^2/2g$ as follows: This head loss is $h = C(u^2/2g)$, where C is a constant coefficient depending only on the type of entrance and exit of the tubes. Values for C as found by Guy and Winstanley (5) are 1.5 for tubes ferruled at both ends; 1.25 for tubes bellmouthed and expanded at the inlet and ferruled at the outlet; and 1.00 for tubes bellmouthed at the inlet and expanded at the outlet.

(c) *Condenser-Piping and Water-Box Losses.* The loss of hydraulic head through the condenser piping and water boxes is entirely dependent on the dimensions of a particular condenser unit under consideration. The author will give the calculations for this loss in main unit No. 13 at the Delray Station of the Detroit Edison Company, which was described in a previous paper (6), and then compare them with test results. The 50,000-sq ft single-pass condenser, previously described by the author (6), had a good hydraulic circuit free from unnecessary obstructions. It was designed for a maximum capacity of 120,000 gpm at a total head of 20 ft.

In considering the water flow through irregular shapes and around irregular corners, it is found that the principal losses arise from acceleration and retardation of the water flow, and are not caused by friction. To prove this, assume that the condenser piping and boxes, which in this case have an average area of 30 sq ft, are replaced by a straight pipe line of equivalent area and length. This would be a pipe line of $6^1/_4$ ft diameter with a length of 70 ft along the flow. The friction loss through this straight pipe line would be only 0.1 ft at a flow of 100,000 gpm. This is negligible, as it is not even 1.5 per cent of the 9-ft head loss actually found in the condenser piping and water boxes.

The actual losses are due principally to the sudden changes of direction in the water flow. Assume that we have a 90-deg elbow in a pipe line and that the elbow is a 45-deg miter joint having only one weld. The energy of the water coming from the one direction is of no use to the water going around the sharp corner and the head loss is 110 per cent of the velocity head (7). In a hydraulic circuit of a condenser we have many of these cases. For instance, the horizontal canal velocity at the entrance of the suction pipe of a circulator is virtually of no use for the vertical velocity in the suction pipe.

All the changes of flow in a hydraulic circuit of a single-pass condenser are:

1 Horizontal canal velocity to vertical suction-pipe velocity of circulators.

2 Vertical inlet-water-box velocity to horizontal tube velocity.

3 Horizontal tube velocity to vertical outlet-box velocity at tube-head side of weir (as is the case in Fig. 3 where the weir is parallel with the tube sheet and flat head).

4 Vertical velocity at tube-head side of weir to horizontal velocity over weir.

5 Horizontal weir velocity to vertical velocity in outlet box flat-head side.

6 Vertical velocity in tail pipe to horizontal velocity in canal.

In all these cases a full velocity-head loss, based on mean velocity, can be assumed for the head-loss calculation.

Naturally, other losses can occur, such as those due to contractions of areas; the velocity head calculated from an equal velocity over the area is then too low and the velocity head has to be recalculated from the actual velocity in the contracted area. For a certain flow, the velocity should be calculated from the product of the area present and the contraction factor for the flow.

The largest losses in the hydraulic circuit of a condenser occur at the outlet-box weir. Energy losses due to change of flow as well as to contraction take place at that point. In the overflow of the weir, especially large contraction takes place, and we even find reversals of flow in this part of the condenser (8).

Results and Testing

The static pressures at different points have to be measured in order to test a hydraulic circuit of a condenser. A diagram of the hydraulic circuit of No. 13 condenser at Delray is shown in Fig. 3, with the location of the places where these static pressures were measured. The elevation in feet above the condenser-room floor is noted at each connection for potential head correction, referring all total heads to condenser-room floor. Any other level, however, can be taken. The total head is the static head, plus the potential head, plus the velocity head. No velocity head has to be included for the top of the inlet box or the outlet box and the canal levels, since it is negligible at these points.

In Table 1 are given the results for some summer and winter tests on this condenser and for some tests of the Trenton Channel condensers Nos. 2 and 3. From these tests, the friction coefficients are calculated and shown in Fig. 4. The results from the

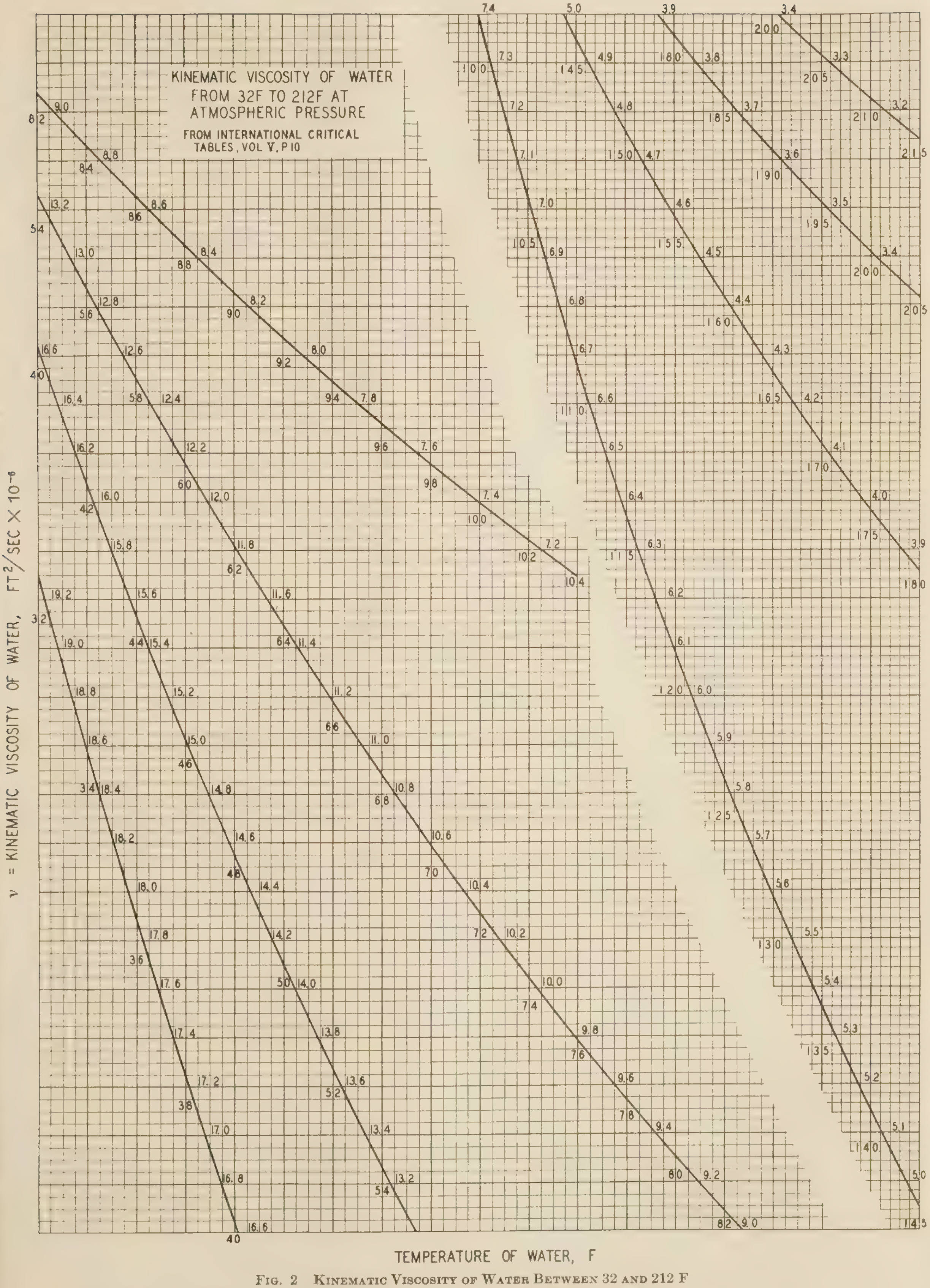


FIG. 2 KINEMATIC VISCOSITY OF WATER BETWEEN 32 AND 212 F

(These values are computed from those of the International Critical Tables, and are applicable to pressures of 1 atm or less.)

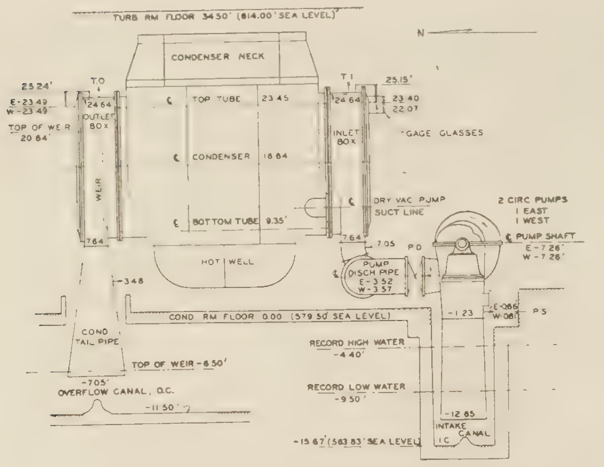


FIG. 3 HYDRAULIC-CIRCUIT ELEVATION OF THE NO. 13 MAIN CONDENSER AT THE DELRAY STATION

(This figure indicates the elevations of the manometer connections, which are marked by crosses, and the elevations of the water-box gage glasses. The locations of the different parts of the circuit are designated by the following letters: Intake canal, I. C.; circulating-pump suction, P. S.; circulating-pump discharge, P. D.; top of inlet water box, T. I.; top of outlet or overflow water box, T. O.; and the overflow canal, O. C. The discharge of each pump has two manometer connections. The outlet water box, divided through its center by a vertical partition into east and west sections, has a manometer connection to each section and a gage glass in each section. For a perspective diagram of this condenser see Fig. 2, p. 629, Trans. A.S.M.E., vol. 58, 1936.)

Delray condenser are somewhat higher, probably because of slight dirtiness of the tubes and also because the friction of the tube cannot be exactly separated from the total losses measured.

Table 2 shows the calculations for 100,000 gpm (two pumps) and 50,000 gpm (single pump) water flow through this condenser. The losses are calculated separately for each point of the circuit where they occur. They are grouped together for each section of the circuit between two successive points of measurement, shown in Fig. 3 and given in Table 1, items 41 to 46 inclusive.

The losses through the tubes are calculated under the heading of "top inlet box–top outlet box" in Table 2. In this loss a part of the weir loss is also included. This loss, with the inlet and outlet losses of the tube, has to be subtracted from the measured results between the top inlet box and the top outlet box to obtain the friction loss through the tube. The friction coefficient λ can then be calculated. Weir losses do not have to be deducted in the case of Trenton Channel condenser No. 3 since it had no weir (9). Fig. 4 shows how remarkably well λ calculated from test data agrees with the theoretical value, especially for the Trenton Channel tests.

A good idea of the change of the losses in the hydraulic circuit with change in water flow can be obtained by plotting a curve, as shown in Fig. 5. This curve also shows the consistency of, and gives a check on, the test results. This can be done for all other drops of the circuit except for top in–top out, where changes of the friction coefficient λ with the Reynolds number are involved.

TABLE 1 SUMMARY OF DATA AND RESULTS OF HYDRAULIC-CIRCUIT TESTS[a]

Item			Delray No. 13 Condenser — Weir in 8143 tubes[b]									
1.	Run No.		65	66	67	68	49	50	51	52	20	22
2.	Date (duration 1-1/2 hour in most cases)		1/7/36	1/7/36	1/7/36	1/7/36	8/13/35	8/13/35	8/13/35	8/13/35	4/4/35	4/4/35
3.	Average inlet temperature of circulating water	F	32.97	33.02	33.21	33.28	75.99	75.74	75.59	75.47	40.12	40.77
4.	Average outlet temp of circ water in tail pipe top	F	39.26	39.85	40.87	42.10	82.59	82.85	83.48	84.47	50.50	53.41
5.	Load at generator terminals	kwhr/hr	49580	49720	49910	49640	49630	49490	49390	49290	49280	49540
6.	Circulators running		2	2	2	2	2	2	2	2	1-E	1-E
7.	Average speed of circulators	rpm	237.4	221.2	200.7	178.2	235.0	221.9	200.3	178.0	239.8	199.3
8.	Total d-c power input to circulating pump motors	kw	617	496	366	259	586	486	358	254	308	178
	Circulating Water Flow by Heat Balances											
9.	Heat given up by condensed steam to circ water	millions Btu/hr	354.2	353.0	353.9	351.0	372.9	372.5	372.9	374.3	345.5	345.9
10.	Circ water enthalpy rise	Btu/lb	6.31	6.85	7.67	8.82	6.59	7.09	7.87	8.98	10.40	12.66
11.	Circ water flow through condenser tubes by heat balance	gal/min	112100	102900	92150	79450	113000	104930	94660	83280	66350	54560
12.	Generator losses (rejected to circ water through gen air cooler)	kw	1390	1390	1390	1380	1375	1380	1390	1390	1390	1390
13.	Circ water temperature rise through generator air cooler	F	14.26	13.64	26.42	29.03	4.09	4.53	5.08	9.94	33.51	21.99
14.	Circ water flow through generator air cooler by heat balance	gal/min	660	690	360	320	2290	2070	1860	950	280	430
15.	Total delivery of circulators (item 11) + (item 14)	gal/min	112760	103590	92510	79770	115290	107000	96520	84230	66630	55990
	Water Velocities and Velocity Heads[c] at Manometer Connections											
16.	Velocity in east circulator 54-inch suction pipe	ft/sec	8.00	7.38	6.60	5.69	8.16	7.62	6.89	6.00	9.33	7.79
17.	Velocity head in east circulator 54-inch suction pipe	ft H_2O	1.00	0.85	0.66	0.52	1.04	0.90	0.74	0.56	1.35	0.92
18.	Velocity in east circulator 48-inch discharge pipe	ft/sec	10.13	9.34	8.35	7.20	10.34	9.64	8.72	7.58	11.82	9.93
19.	Velocity head in east circulator 48-inch discharge pipe	ft H_2O	1.60	1.36	1.06	0.83	1.66	1.44	1.18	0.89	2.16	1.53
20.	Velocity in west circulator 54-inch suction pipe	ft/sec	7.79	7.13	6.36	5.48	7.98	7.37	6.63	5.80	0	0
21.	Velocity head in west circulator 54-inch suction pipe	ft H_2O	0.97	0.79	0.64	0.46	0.99	0.85	0.68	0.52	0	0
22.	Velocity in west circulator 48-inch discharge pipe	ft/sec	9.86	9.02	8.05	6.94	10.11	9.32	8.39	7.35	0	0
23.	Velocity head in west circulator 48-inch discharge pipe	ft H_2O	1.51	1.26	1.04	0.73	1.59	1.35	1.09	0.84	0	0
	Circulating Water Static Pressures (Gage) Measured by Manometers[e]											
24.	East circulator 54-inch suction pipe	ft H_2O	-9.73	-9.38	-9.15	-8.89	-8.08	-7.88	-7.58	-7.28	-9.33	-8.60
25.	East circulator 48-inch discharge pipe at C.L.	ft H_2O	6.74	4.53	1.97	-0.62	6.99	5.30	2.52	0.22	0.71	-2.24
26.	West circulator 54-inch suction pipe	ft H_2O	-9.98	-9.71	-9.33	-9.04	-8.33	-8.10	-7.78	-7.39	..	..
27.	West circulator 48-inch discharge pipe at C.L.	ft H_2O	7.27	5.01	2.28	-0.41	7.59	5.71	2.96	0.41	..	..
28.	Condenser inlet water box at top	ft H_2O	-14.96	-17.01	-19.47	-21.96	-14.51	-16.20	-18.76	-21.06	-23.61	-25.59
29.	Condenser outlet water box at top	ft H_2O	-22.72	-23.71	-24.85	-25.87	-22.20	-23.07	-24.37	-25.29	-26.88	-27.00
	Circulating Water Levels, Referred to C.R.F.[d]											
30.	Intake canal at east circulator suction pipe	ft	-8.83	-8.74	-8.75	-8.67	-7.19	-7.10	-7.00	-6.96	-7.61	-7.57
31.	Intake canal at west circulator suction pipe	ft	-9.11	-8.97	-8.78	-8.68	-7.41	-7.30	-7.20	-7.06	..	..
32.	Overflow canal at condenser tail pipe	ft	-3.92	-4.13	-4.32	-4.44	-3.98	-4.15	-4.23	-4.48	-4.73	-4.96
33.	Condenser inlet water box at top	ft	24.74	24.67	24.63	24.58	24.77	24.73	24.68	24.60	24.28	24.37
34.	Condenser outlet water box at top	ft	24.71	24.68	24.63	24.44	24.80	24.79	24.74	24.53	24.45	23.74
	Total Heads (Static + Potential + Velocity Heads), Refd to C.R.F.[d,f]											
35.	East circulator 54-inch suction	ft H_2O	-9.39	-9.19	-9.15	-9.03	-7.70	-7.64	-7.50	-7.38	-8.64	-8.43
36.	East circulator 48-inch discharge	ft H_2O	11.86	9.41	6.55	3.73	12.17	10.26	7.22	4.63	6.39	2.75
37.	West circulator 54-inch suction	ft H_2O	-9.62	-9.53	-9.30	-9.19	-7.95	-7.86	-7.71	-7.48	..	..
38.	West circulator 48-inch discharge	ft H_2O	12.35	9.84	6.89	3.89	12.75	10.63	7.62	4.82	..	..
39.	Condenser inlet water box at top (neglecting air liberation)	ft H_2O	9.78	7.66	5.16	2.62	10.26	8.53	5.92	3.54	0.67	-1.22
39A.	Condenser inlet water box at top (considering air liberation)[g]	ft H_2O	9.65	7.47	4.89	2.27	10.17	8.41	5.74	3.28	0.27	-1.74
40.	Condenser outlet water box at top (neglecting air liberation)	ft H_2O	1.99	0.98	-0.23	-1.43	2.60	1.72	0.38	-0.76	-2.43	-3.26
40A.	Condenser outlet water box at top (considering air liberation)[g]	ft H_2O	1.37	0.30	-1.01	-2.25	2.17	1.25	-0.17	-1.41	-3.22	-4.04
	Circulating Water Losses of Total Head											
41.	Intake canal to east circulator suction (I.C. - E.P.S.)	ft H_2O	0.56	0.45	0.40	0.36	0.51	0.54	0.50	0.42	1.03	0.86
42.	Intake canal to west circulator suction (I.C. - W.P.S.)	ft H_2O	0.51	0.56	0.52	0.51	0.54	0.56	0.51	0.42	..	..
43.	East circulator discharge to top inlet box (E.P.D. - T.I.)	ft H_2O	2.21	1.94	1.66	1.46	2.00	1.85	1.48	1.35	6.12	4.49
44.	West circulator discharge to top inlet box (W.P.D. - T.I.)	ft H_2O	2.70	2.37	2.00	1.62	2.58	2.22	1.88	1.54	..	..
45.	Top inlet box to top outlet box (T.I. - T.O.)	ft H_2O	8.28	7.17	5.88	4.52	8.00	7.16	5.91	4.69	3.49	2.29
46.	Top outlet box to overflow canal (T.O. - O.C.)	ft H_2O	5.29	4.43	3.31	2.19	6.15	5.40	4.06	3.07	1.51	0.93
47.	Overflow and intake canals (O.C. - I.C.)	ft H_2O	5.05	4.73	4.45	4.24	3.32	3.05	2.87	2.53	2.88	2.61

[a] All condensers are single pass.

[b] Tubes in all cases are brass; 1 in. O.D., 0.902 in. I.D., 24 ft long.

[c] Velocities and velocity heads are computed from division of circulating water flow (heat balance) by flow areas.

[d] C.R.F. = condenser room floor; water standing still with a static pressure of 1 atmosphere abs at the condenser room floor level would have a total head of 0.00 ft. Minus signs indicate distance of water levels below condenser room floor; water levels above condenser room floor have plus signs.

[e] 30-inch manometers filled with mercury or acetylene tetrabromide; minus sign indicates vacuum. Fig. 3 shows locations of connections for Delray No. 13, which were 1/4-inch diameter flush holes. Pump suction and discharge static pressures as listed have been corrected to elevation of manometer connections, which are given in the following table for the different condensers, in feet referred to the condenser room floor:

Item	Condenser:	Delray 13	Trenton 2	Trenton 3
	Circulator Manometer Connections			
24	EPS	-0.66	-2.71	-2.64
25	EPD	3.52	3.14	3.17
26	WPS	-0.61	-2.72	-2.59
27	WPD	3.57	3.22	3.31
	Circulator Shaft C.L.	7.26	6.81	6.73
	Top of Inside of Water Boxes	24.64	22.18	22.15

The Efficiency of the Hydraulic Circuit

By efficiency is meant the ratio of the useful head spent to the total head spent. The useful head in a condenser is assumed to be the head spent on the friction of the tubes plus inlet and outlet losses of the tubes. The total head spent is the total head on the circulators. In the Delray case, run No. 65 for 2 pumps, full load, this efficiency is low, being (6.35 ft of water)/(21.61 ft of water) = 29.5 per cent when including the sealing-weir losses in the overflow canal. For special reasons, however, the overflow canal was built at a higher level than the inlet canal as shown in Fig. 3, and a loss due to a sealing weir in the overflow canal is included in the total head of the pumps. Without this canal-weir loss of 5.05 ft, the efficiency is 6.35/16.56 = 38.5 per cent. This figure is a little above the average, since the inlet and outlet boxes were designed with no horizontal braces, and every effort was made to have a perfect hydraulic pipe system.

In the Delray condenser, 100 — 38.5 = 61.5 per cent of the total head is spent uselessly. Of this, the largest losses occur at the outlet-box weir. Part of the losses due to this weir are included in the losses from the top outlet box to the overflow canal. In the case for 100,000 gpm (see Table 2), they are 3.10 ft of water. To this, the losses due to the upward flow at the tube-head side of the weir and over the weir have to be added. These were included in the head loss between top inlet box and top outlet box. These last losses are respectively 1.38 and 0.62 ft of water; thus, a total of 5.10 ft of water or 5.10/14.46 = 35 per cent of the total-head loss through the condenser boxes, piping, and tubes (sealing weir in overflow canal and canal losses excluded) was spent on the weir. If expressed as a percentage of all losses outside the tubes (sealing weir and canal losses excluded), this becomes 5.10/9.05 = 57 per cent. The largest gain in the hydraulic circuit can therefore be made by removing the weir from the outlet box.

TABLE 1 (*Continued*)

Item	Trenton No. 2, Weir in: 26 of 28 weir cover plates in, 7590 Tubes[b]			Trenton No. 2, Weir in: All 28 cover plates of weir out, 5112 Tubes[b]			Trenton No. 3: Lower half of weir out, 5100 Tubes[b]		
1.	A	B	C	A	B	E	F	E	2
2.	4/16/31	4/16/31	4/16/31	9/16/31	9/16/31	9/16/31	8/23/34	8/23/34	5/10/33
3.	48.0	48.4	48.8	71.8	71.9	72.2	72.25	71.92	49.00
4.	57.7	61.0	64.4	82.0	85.4	84.0	79.16	80.72	59.34
5.	50700	50900	50700	50700	49700	35000	39920	39860	39790
6.	2	2	2	2	2	2	2	2	2
7.	247.9	191.4	160.0	249.8	191.4	169.3	253.6	201.7	169.3
8.	517	240	144	517	236	164	572	285	164
9.	469	469	474	468.5	465.8	338.2	369.7	368.0	349.9
10.	9.7	12.6	15.6	10.2	13.6	11.1	6.89	8.77	10.34
11.	96800	74400	60800	91700	68600	60900	107200	83800	67600
12.	1510	1520	1510	1460	1430	1340	1450	1450	1420
13.	12.2	16.4	20.4	3.6	4.7	4.8	3.13	3.76	5.95
14.	840	630	500	2800	2100	1900	3160	2630	1600
15.	97600	75000	61300	94500	70700	62800	110400	86400	69210
16.	6.8	5.3	4.3	6.7	5.0	4.4	7.7	6.1	5.0
17.	0.71	0.43	0.28	0.69	0.38	0.30	0.93	0.58	0.38
18.	8.7	6.7	5.5	8.5	6.4	5.6	9.8	7.7	6.3
19.	1.17	0.70	0.46	1.13	0.63	0.49	1.49	0.92	0.61
20.	6.8	5.3	4.3	6.7	5.0	4.4	7.6	6.0	4.8
21.	0.71	0.43	0.28	0.69	0.38	0.30	0.91	0.57	0.35
22.	8.7	6.7	5.5	8.5	6.4	5.6	9.7	7.7	6.0
23.	1.17	0.70	0.46	1.13	0.63	0.49	1.45	0.91	0.56
24.	-4.35	-3.50	-3.14	-3.99	-2.83	-3.06	-4.33	-3.48	-1.99
25.	10.45	3.10	-0.20	12.02	3.51	0.54	8.66	2.64	0.85
26.	-3.40	-2.73	-2.60	-2.96	-2.32	-2.57	-4.59	-3.62	-2.08
27.	10.26	3.12	-0.31	11.96	3.91	0.80	8.76	2.79	0.95
28.	-9.99	-16.10	-19.40	-8.76	-16.09	-18.70	-11.32	-16.80	-18.43
29.	-15.78	-20.82	-22.25	-20.19	-21.49	-22.03	-22.63	-23.36	-21.71
30.	-5.08	-4.96	-4.92	-4.50	-4.38	-4.80	-5.49	-5.24	-4.08
31.	-	-	-	-	-	-	-5.44	-5.20	-4.03
32.	-3.69	-3.92	-4.04	-3.13	-3.27	-3.72	-4.61	-4.65	-3.61
33.	22.18	22.13	22.08	22.20	22.13	22.13	21.60	21.66	21.84
34.	21.94	21.66	21.25	20.90	20.46	20.08	20.69	20.20	19.11
35.	-6.35	-5.78	-5.57	-6.01	-5.16	-5.47	-6.04	-5.54	-4.25
36.	14.76	6.94	3.40	16.29	7.28	4.17	13.32	6.73	4.63
37.	-5.41	-5.02	-5.04	-4.99	-4.66	-4.99	-6.27	-5.64	-4.32
38.	14.65	7.04	3.37	16.31	7.76	4.51	13.52	7.01	4.82
39.	12.19	6.03	2.68	13.44	6.04	3.43	10.28	4.86	3.41
39A.	12.15	5.88	2.44	13.41	5.92	3.25	10.23	4.73	3.20
40.	3.16	0.84	-1.00	0.71	-1.03	-1.95	-1.94	-3.16	-2.60
40A.	2.79	0.39	-1.54	0.39	-1.41	-2.33	-2.35	-3.62	-2.77
41.	1.27	0.82	0.65	1.51	0.78	0.67	0.54	0.30	0.17
42.	0.33	0.06	0.12	0.49	0.28	0.19	0.83	0.44	0.29
43.	2.61	1.06	0.96	2.88	1.36	0.92	3.09	2.00	1.43
44.	2.50	1.16	0.93	2.90	1.84	1.26	3.29	2.28	1.62
45.	9.36	5.49	3.98	13.02	7.33	5.58	12.58	8.35	5.97
46.	6.48	4.31	2.50	3.52	1.86	1.39	2.26	1.03	0.84
47.	1.39	1.04	0.88	1.37	1.11	1.08	0.86	0.57	0.45

[f] Intake and overflow canals' total heads are taken as their levels, items 30, 31, and 32.

[g] For computation of items 39A and 40A, see Table III, items 19 and 13 respectively.

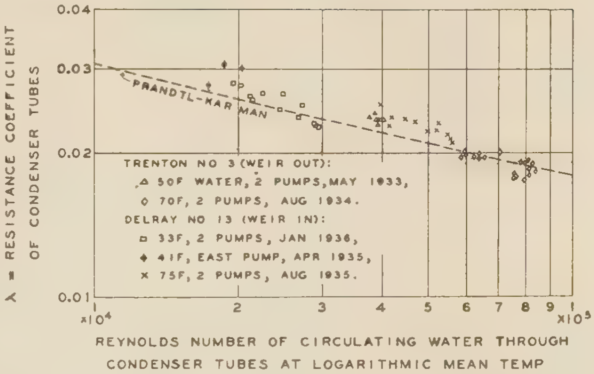


Fig. 4 The Resistance Coefficient λ for Condenser Tubes Versus Reynolds' Numbers of the Circulating Water at the Logarithmic Mean Temperature of the Water

(This figure shows the striking suitability of the Prandtl-von Kármán formulation of Nikuradse's tests of a single tube for condenser-tube banks, which is shown in Fig. 1. The resistance coefficient is for the tube-wall friction only. The Reynolds numbers are calculated from the water velocity through the tubes by the heat-balance value, at the logarithmic mean temperature of the water through the tubes. For the No. 13 condenser at the Delray Station, they are the Reynolds numbers of item 74 in Table 1 of a previous paper by the author (6). Many more test points could have been shown, but those shown are examples of winter and summer test results.)

From each of the existing single-pass condensers Nos. 1, 2, and 3 at the Trenton Channel plant, the author removed an outlet-box weir which was similar to that used on Delray No. 13 condenser, and by doing so increased the efficiency of the circuit from around 28 per cent to around 63 per cent, as shown in Table 1. Part of this high increase in efficiency was due to the additional obstruction in the original design caused by the four butterfly valves in the outlet box (10). This, however, cannot always be done, and will depend on the design of the condenser. A new condenser can be designed without a weir.

The gains involved in the hydraulic circuit by improving its design are therefore worth consideration. For the Trenton Channel and Delray Stations, the average auxiliary power for the circulators is 0.5 per cent of the total generator output under winter conditions, and 1 per cent under summer conditions. For this favorable case of 35 per cent gain in hydraulic-circuit efficiency, a gain of 0.17 to 0.35 per cent of the total generator output is obtained, depending on winter or summer operating conditions.

For a new station, however, it would mean a worthwhile initial reduction in the required installation of auxiliary turbogenerator capacity, as the circulator power runs from 20 to 40 per cent of the total auxiliary power of the station, depending on winter or summer conditions.

Also, in cases where the water quantity is too small, a considerable increase of water can be obtained by taking out the weir; in the case of units Nos. 1, 2, and 3 of the Trenton Channel Station, the increase of water quantity ran around 15 per cent for the same load on the circulators.

The Circulators

Only circulators of high specific[3] speed can be used because of their low head and high capacity. From an operating point of view, the head of the pump at the shutoff point (that is, the point of zero capacity) should be so high at the highest speed

[3] The specific speed N_s of a centrifugal pump on a gallon-per-minute basis is calculated as $(N\sqrt{G})/H^{3/4}$, where N = pump speed, rpm; G = delivery, gpm; and H = total head, ft.

TABLE 2 THEORETICAL METHOD OF CALCULATION OF HEAD LOSSES THROUGH HYDRAULIC CIRCUIT

(For Delray No. 13 Main Condenser Hydraulic Circuit)

Condition of Operation	(1) Area Sq ft	(2) Contraction Area	(3) = (1)x(2) Actual Flow Area Sq ft
A. INLET CANAL - PUMP SUCTION (I.C. - P.S.)			
1. Vertical Area East Pump 5'3" diameter	16.77	None	16.77
B. PUMP DISCHARGE - TOP INLET BOX (P.D. - T.I.)			
2. Vertical Area Fabricated Elbow 48" diameter	12.57	None	12.57
3. Vertical Area at Entrance of Mixing Box 48" diameter	12.57	None	12.57
4. Horizontal Area at Exit of Mixing Box	27.40	None	27.40
C. TOP INLET BOX - TOP OUTLET BOX (T.I. - T.O.)			
5. Vertical Area through 8143 Tubes 1" O.D., No. 18 BWG.	$\frac{L}{D}$ = 319		
6. Inlet and outlet Losses	36.13	-	-
7. Friction Losses at 32 F			
8. Horizontal Area at Top of Weir at Tube Sheet Side	20.64[c]	None	20.64[c]
9. Vertical Area over Top of Weir	39.31	0.90	35.38
D. TOP OUTLET BOX - OVERFLOW CANAL (T.O. - O.C.)			
10. Horizontal Area at Top of Weir at Flat Head Side	26.30	0.60	15.79
11. Horizontal Area at Outlet Nozzle	29.27	None	29.27
12. Horizontal Area at Outlet Tail Pipe	32.91	None	32.91
13. Vertical Area at Outlet Tail Pipe	90.90	0.80	72.70

[a] 0.10 for gate valve plus 0.50 for fabricated elbow plus 0.05 for expansion joint.

[b] The mixing box at the bottom of the inlet water box is similar to that shown in Figs 117 and 118, p 661, Engineering, June 1, 1928, Vol 125. It has a longitudinal partition so that the water from each pump enters the bottom of the inlet water box across its full width of 12 feet. A symmetry of flow with two-pump operation gives a more favorable turning condition in this mixing box than with one-pump operation. Consequently, a loss of 25% of the velocity head for two-pump operation and of 100% for one-pump operation is assumed.

that the pump can push the water over the weir or highest point of the circuit. In that case, and with a valve in the discharge end of the circulator, the priming of the pump only is necessary to get the water over the weir. If this is not the case, the whole hydraulic circuit has to be primed and this is a handicap to the quick starting of the unit. The priming of the whole circuit takes about 15 minutes against 2 to 3 minutes for a pump alone.

The shut-off point of the circulator will always be high enough to put the water through the circuit if the weir is omitted. When a submerged type of screw pump is used with no weir, all priming lines can be omitted and only vent lines are installed, simplifying the circuit and saving time in starting up.

The Air in the Hydraulic Circuit

Although the siphonic losses have been overestimated, they cannot be ignored in an accurate study of the hydraulic circuit, especially when the siphon is high. A short-cut calculation has been given by Guy and Winstanley (11).

A more accurate calculation will be given. First the amount of air liberated is calculated and then the new density of the water due to volume changes of the air will be calculated.

Air-Water Weight Ratio. River water is always 100 per cent saturated with air, although the ratio of oxygen to nitrogen in the water is somewhat larger than that in the atmospheric air. This difference, however, can be neglected in this calculation. With the use of Henry's law and of the data of Professor Winkler for air dissolved in water under a total pressure of one atmosphere, it is possible to calculate for any condition the volume of the air-water mixture per pound of dry air in the mixture in the circuit. From Henry's law it is known that the amount of a gas dissolved in a liquid is proportional to the partial pressure of that gas on the liquid. Fig. 6 has been calculated from Winkler's 1901 data (12). The weight of air lib-

TABLE 3 EFFECT OF LIBERATED AIR ON CIRCULATING WATER TOTAL HEADS AT TOP OF INLET AND OUTLET WATER BOX

(Delray No. 13 Main Condenser Hydraulic Circuit Tests)

Item					
1. Run No.		65	63	20	22
Date		1/7/36	1/7/36	[illegible]	4/[illegible]/35
2. Barometer	in. Hg at 32 F	29.77	29.34	29.58	[illegible]
3. Circulating water inlet temperature	F	33.0	33.3	40.1	40.5
4. Circulating water outlet temperature	F	33.3	42.1	50.5	53.4
5. Weight ratio of dissolved air to water for saturated solution at inlet conditions, items 2 and 3. From Fig. 6		36.35×10^{-6}	[illegible]	33.21×10^{-6}	[illegible]
OUTLET WATER BOX:					
6. Pressure at which air liberated in condenser is fully redissolved at circ water outlet temp. From items 5 and 4 and Fig. 6	in. Hg abs at 32 F	32.50	33.68	33.80	34.60
7. Distance inside condenser tail pipe below overflow canal level at which static pressure equal to item 6 occurs. [(Item 6) - (item 2)] x (13.596/12)	ft	3.09	4.3[illegible]	4.79	5.73
8. Circ water level difference, top outlet box - overflow canal. (Item 34 of Table I) - (item 32 of Table I)	ft	28.63	[illegible]	29.18	28.70
9. Height of overflow water column containing free air. (Item 7) + (item 8)	ft	31.72	33.[illegible]3	33.97	34.43
10. Pressure at top of overflow water column. (Item 2) - [(item 29 of Table I) x (12/13.596)]	in. Hg abs at 32 F	9.72	7.03	5.87	5.74
11. Decrease of mean density of height of overflow water column because of free air. From items 10 and 4, and Fig. 8	%	1.34	2.48	2.39	2.25
12. Correction to calculation of total head in top of outlet water box because of free air. (Item 9) x [-(item 11)/100]	ft H_2O	[illegible]	-0.82	-0.79	-0.78
13. Circ water total head in top of outlet water box, considering free air, refd to C.R.F. and gage pressure. (Item 12) + (item 29 of Table I) + (item 34 of Table I), which is item 40A of Table I	ft H_2O	1.37	-2.25	-3.22	-4.34
INLET WATER BOX:					
14. Distance inside inlet water box above condenser room floor at which static pressure is equal to atmospheric pressure, item 2. 1/2(3.52 + 3.57)ft + 1/2 [(item 25 of Table I) + (item 27 of Table I)]	ft	10.35	3.33	4.23	1.28
15. Height of inlet-box water-column containing free air. (Item 33 of Table I) - (item 14)	ft	1[illegible].19	21.5[illegible]	20.05	23.0[illegible]
16. Pressure at top of inlet-box water-column. (Item 2) - [(item 28 of Table I) x (12/13.596)]	in. Hg abs at 32 F	16.56	[illegible]	8.74	6.9[illegible]
17. Decrease of mean density of height of inlet-box water-column because of free air. From items 16 and 3 and Fig. 8	%	0.94	1.4[illegible]	1.94	2.25
18. Correction to calculation of total head in top of inlet water box because of free air. (Item 15) x [-(item 17)/100]	ft H_2O	-0.13	-0.35	-0.40	-0.52
19. Circ water total head in top of inlet water box, considering free air, refd to C.R.F. and gage pressure. (Item 18) + (item 28 of Table I) + (item 33 of Table I), which is item 39A of Table I	ft H_2O	3.65	[illegible]	0.27	-1.74

TABLE 2 (*Continued*)

100,000 gpm - two pumps running				
(4) = 112/(3)	(5) = 223/(3)	(6) = (4) or (5)²/2g	(7)	(8) = (7)x(6)
Velocity (for 112 cu ft/sec) ft/sec	Velocity (for 223 cu ft/sec) ft/sec	Velocity Head ft H_2O	Head Loss in % of Velocity Head	Total Head Loss ft H_2O
6.65		0.68	100	0.68
			Total A = (1) =	0.68
8.90		1.23	65[a]	0.80
8.90		1.23	25[b]	0.31
	8.14	1.03	100	1.03
			Total B = (2)+ (3)+ (4) =	2.14
-	6.17	0.59	125	0.74
	λ = 0.0248			4.67
	9.43[c]	1.38	100	1.38
	6.31	0.62	100	0.62
			Total C = (5)+ (6)+ (7) + (8)+(9) =	7.41
	14.13	3.10	100[d]	3.10
	7.62	0.90	30[e]	0.27
	6.77	0.71	100	0.71
	3.07	0.15	100	0.15
			Total D = (10)+ (11)+ (12)+ (13) =	4.23
			Grand Total = A+B+C+D =	14.46

50,000 gpm - one pump running			
(9)	(10) = (9)²/2g	(11)	(12) = (10)x(11)
Velocity (for 112 cu ft/sec) ft/sec	Velocity Head ft H_2O	Head Loss in % of Velocity Head	Total Head Loss ft H_2O
6.65	0.68	100	0.68
		Total A = (1) =	0.68
8.90	1.23	65[a]	0.80
8.90	1.23	100[b]	1.23
8.14	1.03	100	1.03
		Total B = (2)+ (3)+ (4) =	3.06
3.09	0.15	125	0.19
	λ = 0.0294		1.41
4.72	0.35	100	0.35
3.16	0.16	100	0.16
		Total C = (5)+ (6)+ (7)+(8)+(9) =	2.11
7.10	0.78	100[d]	0.78
3.81	0.21	30[e]	0.06
3.39	0.18	100	0.18
1.54	0.04	100	0.04
		Total D = (10)+ (11)+ (12)+ (13) =	1.06
		Grand Total = A+B+C+D =	6.9[illegible]

[c]The water flow through this area is from only 7114 tubes, which are located below top of weir.
[d]100% because of the abrupt change in water box section at weir top and at bottom of overflow box.
[e]30% as a diffusor loss of tail pipe.

erated from a pound of water can be obtained from the difference of two ordinates in Fig. 6. For instance, assume the inlet-water temperature to be 40 F, with a barometer of 30 in. Hg, and the outlet-water temperature at the top of the outlet box to be 60 F and at 10 in. Hg abs total static pressure; then the air liberated is found by subtracting 8.5×10^{-6} lb of air per lb of water in the overflow top from 33.8×10^{-6} lb of air per lb of water as present in the original condition, or 25.3×10^{-6} lb of air are liberated per lb of water.

Volume of Liberated Air. When the amount of air liberated is known, its volume can be calculated with the aid of Dalton's law. This has been done in Fig. 7, which directly shows the volume occupied by the air-vapor mixture for every pound of dry air in the mixture. For the example of 10 in. Hg abs pressure and 60 F, this is 41.2 cu ft per lb of dry air. Therefore, the liberated air per pound of water occupies a space $25.3 \times 10^{-6} \times 41.2 = 1.043 \times 10^{-3}$ cu ft.

Change of Water Density Due to Air. Assuming the weight of 1 cu ft of water as 62.43 lb, then the volume of the air liberated in 1 cu ft of water is $1.043 \times 10^{-3} \times 62.43 = 0.0655$ cu ft. In other words, the density of the water containing 100 per cent air has changed from 62.43 lb per cu ft to $62.43/(1 + 0.0655) = 58.55$ lb per cu ft, a change of 6.3 per cent in weight density. With these figures, the new density can be easily calculated for

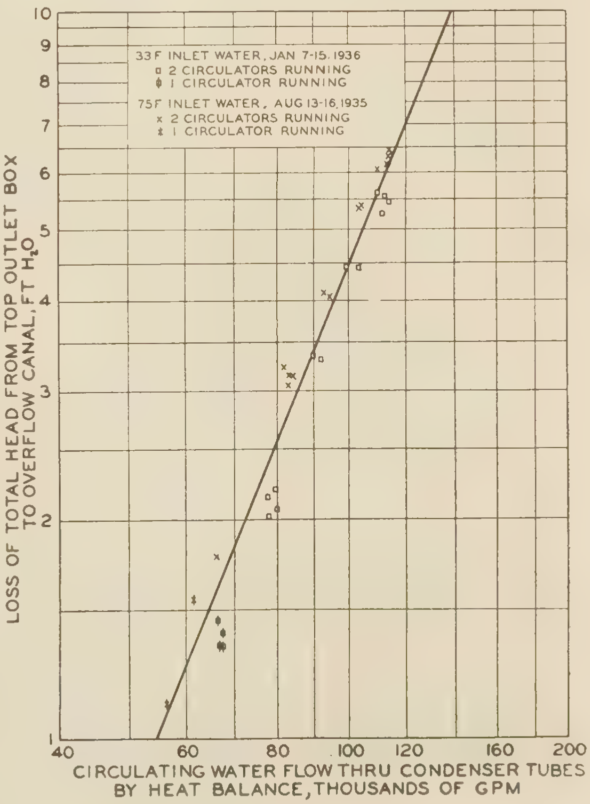


FIG. 5 (RIGHT) LOSS OF TOTAL HEAD FROM TOP OUTLET BOX TO OVERFLOW CANAL VERSUS CIRCULATING-WATER FLOW THROUGH CONDENSER TUBES BY HEAT BALANCE FOR THE NO. 13 CONDENSER AT THE DELRAY STATION

(This total-head loss is item 46 of Table 1, which is the difference between item 40A and item 32 of that table, and allows for the entrained air in the outlet-box water column. The circulating-water flow is item 11 of Table 1. The figure illustrates the straight-line relationship obtained on logarithmic paper for losses between points; the slope of the line is approximately 2.)

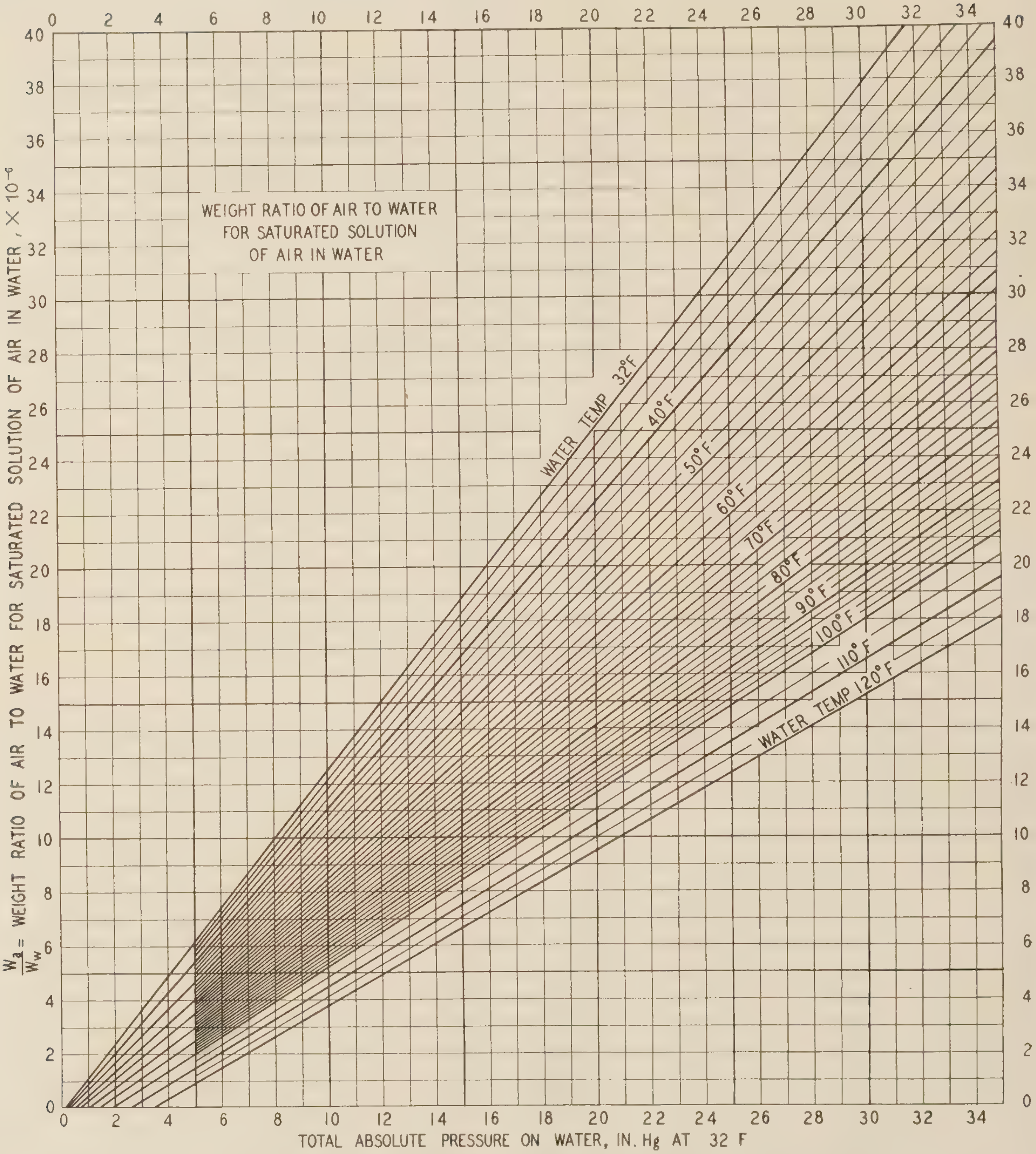


FIG. 6 WEIGHT RATIO OF AIR TO WATER FOR A SATURATED SOLUTION OF AIR IN WATER

(Lines of different water temperature from 32 to 120 F are plotted for total pressures on the water from 0 to 35 in. Hg abs, the total pressure being the sum of the partial pressure of the water vapor and the dry air over that water. The lines are straight because, according to Henry's law, the weight ratio of dissolved air to water is linearly proportional to the partial pressure of the dry air in the mixture of air and water vapor over the water. These data are calculated from the International Critical Tables (12) where is given for different temperatures, the total dry-air content V_d in 1000 cc of water 100 per cent saturated with air at a total pressure of 760 mm Hg; the dissolved-air content is measured in cubic centimeters referred to standard conditions of 0 C and 760 mm Hg. The weight ratio of dissolved air to water is computed as

$$\frac{W_a}{W_w} = \frac{p_a \text{ at } p_t}{p_a \text{ at 29.921 in. Hg}} \times \frac{d_a \text{ at 29.921 in. Hg and 32 F}}{d_w} \times \frac{V_d}{1000}$$

where W_a = weight of dissolved dry air in solution with water 100 per cent saturated with air; W_w = weight of water containing W_a weight of air; p_a at p_t = partial air pressure at total pressure p_t and at the temperature for which V_d is given, in. Hg at 32 F; $p_a = p_t - p_s$; p_s = saturation pressure of steam at the temperature for which V_d is given, in. Hg at 32 F; p_a at 29.921 in. Hg = partial air pressure at 29.921 in. Hg total pressure and the temperature for which V_d is given, in. Hg at 32 F; d_a = standard weight density of air, 1.2929×10^{-3} g per cc, International Critical Tables, vol. 3, p. 3, or 0.080714 lb per cu ft; and d_w = weight density of water at the temperature for which V_d is given, g per cc. Density d_w can be obtained from the International Critical Tables, vol. 3, 1928, p. 25. The graph is based on an identical molecular weight of 28.958 for both dissolved and free air. Actually, dissolved air contains about 13 per cent more oxygen than free air. The composition of air dissolved in 32 F water corresponds to a standard weight of 0.08231 lb per cu ft, and for air dissolved in 86 F water, 0.08212 lb per cu ft.)

any point in the circuit, when the static pressure is known. One problem which is still left is the change in weight density due to the static-pressure changes that occur with change in height of level, because the potential pressure changes. An integration over a certain height of water column is therefore necessary for the different densities. This has been worked out as curves in Fig. 8, which gives the correction for the height of a standing column under different absolute pressures at the top of the column and at different temperatures of the column. The tests (see Table 1) give the level difference between the top of the outlet box and overflow canal. But, at the level of the overflow canal, the water inside the tail pipe still has free air present because it was saturated at inlet temperature and not at outlet temperature. A higher pressure is necessary to redissolve all air at the higher temperature. Fig. 6 gives the pressure at

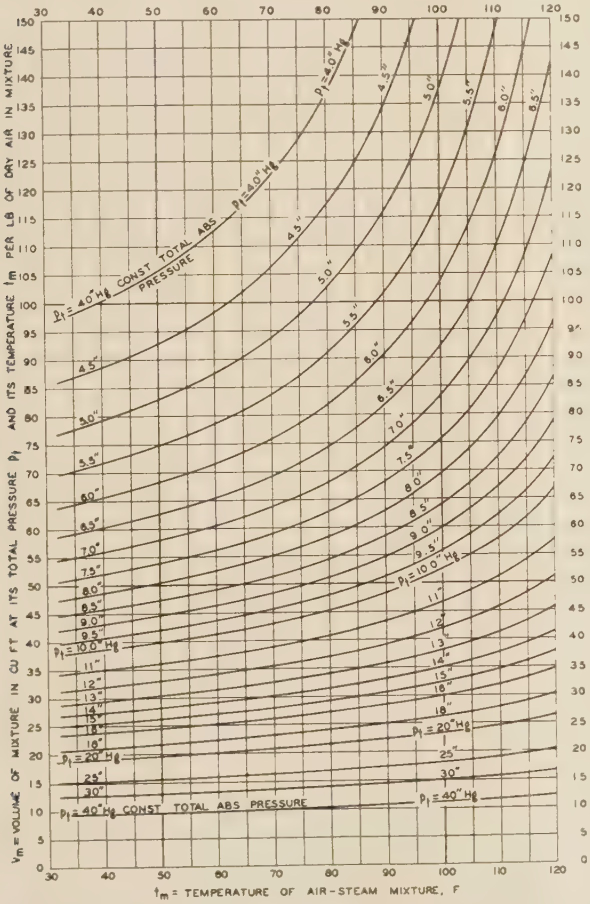


Fig. 7 Volume of Air-Steam Mixture, of 100 Per Cent Relative Humidity, Per Pound of Dry Air at Different Temperatures and Total Pressures of Mixture

(This graph represents the equation $(p_t - p_s)V_m = 0.7541(t_m + 459.6)$ where p_t = total absolute pressure of the mixture, in. Hg at 32 F; t_m = temperature of mixture, deg F; p_s = steam saturation pressure at t_m, in. Hg at 32 F; and V_m = cu ft of mixture per lb of dry air.)

which all the air will dissolve at the higher temperature when moving along a constant ordinate from the lower pressure to the higher pressure, since both conditions have to have the same weight ratio of dissolved air to water. This additional pressure added as feet to the level difference between the top of the outlet box and the overflow canal level gives the total height to be corrected. Fig. 8 gives the correction to be applied for water from 32 to 90 F, and for 30 in. Hg total pressure, and an additional

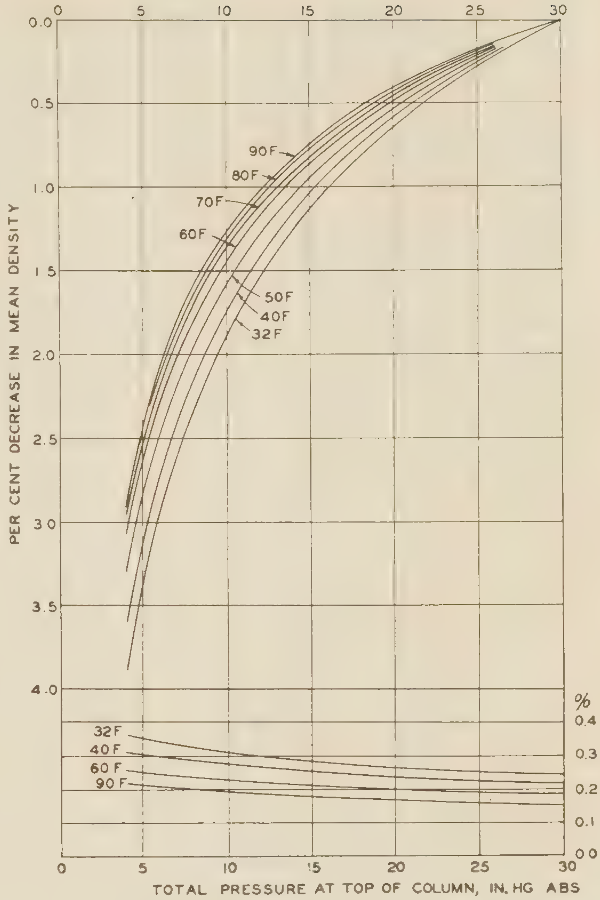


Fig. 8 Correction to Mean Density of Vertical Water Column for Decrease Due to Liberated Air

(The data of the figure have been computed for a standing column, but they apply as well to a column of moving water, providing the change of static pressure from bottom to top is approximately linear. The curves in the upper part of the figure apply to water which is saturated with dissolved air at the regular atmospheric condition which is assumed to be a total pressure of 30 in. Hg. This curve is to be used for the inlet water box where no changes of temperature have taken place as yet. The curves in the lower part of the figure show the minor additional decrease of mean density (at the right of the figure) if the pressure at saturation is 35 in. Hg instead of 30 in. Hg. This has to be applied for the overflow where the temperature rise has raised the saturation pressure.)

correction to be applied in case a total pressure of 35 in. Hg is necessary to redissolve all the air. For total pressures between 30 and 35 in. Hg, a prorata correction has to be applied. Sample calculations for four of the runs are included in Table 3.

It is mentioned here that the siphon losses due to air in the circuit have been overestimated, and that they amount to only 0.5 ft for a 26-ft siphon in case the vent line from inlet to outlet box takes care of the free air.

The downward velocity in the outlet box and tail pipe should always be kept above 1.5 fps so that no liberated air can rise against the flow of water (13, 14). For calculation of thoroughly safe conditions, so that possible air leaks in the hydraulic circuits can be taken care of, it is better to use a value of 2 to 3 fps. (See Table 2, Item 11, column 5 or g.)

Fig. 9, based on data obtained on unit No. 13 at the Delray Station, gives a picture of the flow velocity in the overflow below the joint between the bottom of the outlet box and the top of the tail pipe. The values were obtained from a pitot-tube traverse. Although the velocity at the center dropped considerably, due to the vertical brace in the outlet box, it is clearly noticeable that

in each half of the pipe the highest velocities occur toward the center of the pipe as a whole. This is a result of the flow condition over the top of the weir, where the largest flow occurs toward the center line of the outlet box. At this point the flow area above the weir is a segment of a circle of which the weir top forms the chord.

Venting of Condensers. More attention should be given to the venting of inlet boxes, return boxes, and centrifugal-pump discharges, especially if salt water is used as a cooling medium.

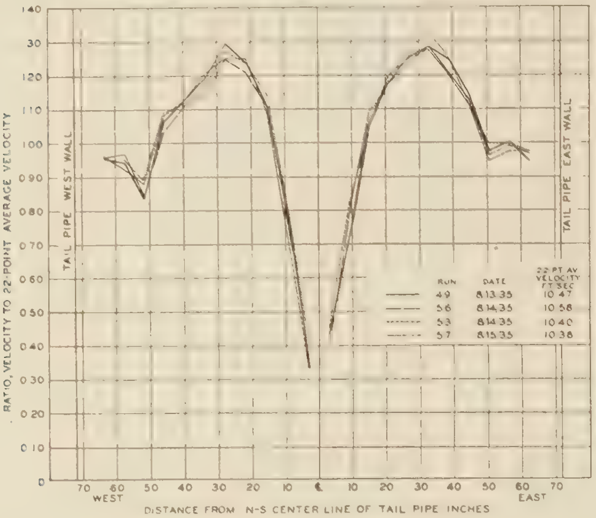


FIG. 9 VELOCITY DISTRIBUTION OF OVERFLOW CIRCULATING WATER ALONG THE LONG CENTER LINE OF THE 30 × 144-IN. TAIL-PIPE TOP FOR NO. 13 CONDENSER AT DELRAY STATION

(These curves, which are for four runs with 75 F inlet circulating water, and with both circulators operating at their highest speed of 240 rpm, are typical of many other runs with both circulators running at equal speeds over the whole speed range of 180 to 240 rpm, and with inlet circulating-water temperatures varying from 40 to 75 F. The traverse was made in the top of the tail pipe close to the location of the outlet thermocouples, or at an elevation of 6.39 ft above the condenser-room floor. It was made with two Cole pitometers, which were adjusted to 22 station points approximately 3 in. apart. The mid-point of each half of the pipe was checked before and after each traverse. Pitometer pressures were measured with 30-in. manometers filled with acetylene tetrabromide. Location of the pitometers is shown in Fig. 2 of a previous paper by the author (6). The decrease in velocity at the center of the pipe is caused by the vertical brace in the center of the outlet box. The traverse was made only 2.5 ft below foot of that brace, which is 10 in. wide and 30 in. long. The tail pipe was braced with five 1/2 × 30-in. braces.)

Bad venting of inlet water boxes will cause the air to flow through the tubes and cause corrosion at the inlet end of the tube, because of the contraction of flow which takes place. Also the heat transfer suffers, especially for the top tubes which will act as vent lines in case the installed vent is not of sufficient capacity.

In general, the vent lines applied are all too small, and have insufficient capacity for handling the volume of rarified air that is liberated. The small amount of pressure drop available from the top inlet to outlet box cannot handle this quantity. For a 50,000-sq ft condenser, a 3 to 4-in. vent line is necessary to handle the air satisfactorily instead of the usual 1 1/2 to 2-in. line.

The worst condition occurs at the lowest circulator speed or smallest circulating water flow through the condenser. Assume that the mean pressure of the water in the inlet box is at its center line; then, the volume of the air liberated from 75,000 gpm of water will be around 6 cfs referred to the pressure at the top of the water box (15). In a 2-in. line, this would give a velocity of 260 fps or 15,600 fpm. Under this condition, a pressure drop of 5.4 in. Hg is available between the inlet and outlet boxes, which is only half the pressure difference necessary to transport this volume of air through a 2-in. vent line.

This problem of air is a serious one. Its existence can be quickly proved by taking a vertical traverse in a horizontal discharge line of one of the pumps to a condenser. Such a test showed that at the top of a 48-in. discharge line of a circulator, a space 2 in. high was occupied by air. The worst condition, such as this one was, will happen when the discharge pressure of the circulator is below atmospheric pressure. Free air from the outside atmosphere is often taken in directly through the suction pipe of the circulator. A hollow swirl which is caused by the prerotation of the circulating water in the suction pipe and which extends into the intake canal will bring this free air directly into the system. In case this happens at the design operation of the pump, its impeller should be redesigned.

A good liberation of the air in the inlet box should be provided for. This can be secured by boxes which allow low water velocities and which are free of obstructions. Consequently, the boxes should be wide and have no horizontal braces.

CONCLUSION

The losses of a hydraulic circuit can be calculated within an accuracy of 10 per cent. The weir in single-pass condensers, and not the siphon, causes the highest losses and should be eliminated whenever possible. Abrupt changes in direction of flow should be eliminated. The entrance losses due to bellmouthed or ferruled tubes are overestimated. The liberated air in the water can be determined under all conditions and should be taken care of by adequate venting, because of the possibility of corrosion under salt-water conditions.

ACKNOWLEDGMENT

The author wishes to acknowledge the opportunity given him by The Detroit Edison Company to obtain and publish these results.

BIBLIOGRAPHY

1 "Neuere Ergebnisse der Turbulenzforschung," by L. Prandtl, *Zeit. V.D.I.*, vol. 77, 1933, pp. 105–114.

2 "Turbulence and Skin Friction," by Th. von Kármán, *Journal of the Aeronautical Sciences*, vol. 1, no. 1, January, 1934, p. 11.

3 "Gesetzmässigkeiten der turbulenten Strömung in glatten Rohren," by J. Nikuradse, Forschungsheft 356, V.D.I., September–October, 1932. Also abstracted, *Zeit. V.D.I.*, vol. 77, 1933, p. 48.

4 "Handbook of Engineering Fundamentals," John Wiley & Sons, Inc., New York, N. Y., 1936, section 6, "Mechanics of Fluids," by P. E. Hemke, formula 38, and Fig. 29, p. 31.

5 "Some Factors in the Design of Surface Condensing Plant," by H. L. Guy and E. V. Winstanley, Proceedings of the Institution of Mechanical Engineers, vol. 126, February, 1934, p. 264.

6 "Tests of a 50,000-Sq Ft Surface Condenser at Widely Varying Temperatures, Velocities of Inlet Water, and Loads," by G. H. Van Hengel, Trans. A.S.M.E., vol. 58, November, 1936, paper FSP-58-10, pp. 627–641.

7 "Loss of Energy in Miter Bends," by Hans Kirchbach, Transactions of the Munich Hydraulic Institute, Bulletin 3, authorized translation made by R. T. Knapp for THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, p. 59. German: *Mitteilungen des hydraulischen Instituts der Technischen Hochschule München* No. 3, edited by D. Thoma, R. Oldenbourg, Munich, 1929, p. 90.

8 "Verminderung des Strömungsverlustes in Kanälen durch Leitflächen," by K. Frey, *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 5, May–June, 1934, pp. 112–113, Figs. 11 to 22, inclusive.

9 "The Trenton Channel Power Station of the Detroit Edison Company," *Engineering*, vol. 125, 1928, p. 670, Figs. 113–116.

10 Ibid., Fig. 114.

11 "Some Factors in the Design of Surface Condensing Plant," by H. L. Guy and E. V. Winstanley, Proceedings of the Institution of Mechanical Engineers, vol. 126, February, 1934, p. 270, Table 7.

12 "International Critical Tables," vol. 3, 1928, p. 258.

13 "Mechanical Engineers' Handbook, II—Power," edited by R. T. Kent, John Wiley & Sons, Inc., New York, N. Y., 1936. Section 2, "Pumps and Pumping Engines," p. 75.

14 "Steiggeschwindigkeit von Luftblasen in Flüssigkeiten," by T. Bryn, *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 4, January–February, 1933, pp. 27–30.

15 "Effect of Air and Turbulence on Condenser-Tube Deterioration," Trans. A.S.M.E., vol. 52, 1930, paper FSP-52-42, p. 357.

Formulas for Stresses in Bolted Flanged Connections

By E. O. WATERS,[1] NEW HAVEN, CONN., D. B. WESSTROM,[2] HARTFORD, CONN., D. B. ROSSHEIM,[3] AND F. S. G. WILLIAMS,[4] NEW YORK, N. Y.

Progress in pressure-vessel design and fabrication during the past two decades has brought about a marked change in the form of bolted connections. Whereas flanges were formerly provided with hubs of approximately uniform thickness, screwed to or slipped over the shell or pipe, it is now customary to use tapered hubs, and an integral structure is obtained by butt welding the end of the hub to the shell. This has invalidated former methods of design for flanged connections.

This paper outlines a revised analysis based on the ring, tapered hub, and shell being considered as three elastically coupled units loaded by a bolting moment, a hydrostatic pressure, or a combination of the two. Design formulas and charts are given for the computation of stresses that are likely to be critical, and their application is illustrated by three problems taken from current commercial practice.

Introduction

FOR THE last two decades there has been a steady increase in the pressures and temperatures employed in the generation of steam and in the process industries. This development has been coincident with a rapid increase in the size of the units. Approximate methods of design that had previously been acceptable could not be used for high-temperature high-pressure designs involving large equipment. With high temperatures and pressures, encroachment on safe operation could not be tolerated; and at the same time, the size of most units demanded economy in design without any compromise with safety. The result has been a steadily increasing need for flange-stress formulas which are correct over a wide range.

During this period, methods of construction have also undergone radical changes. Earlier flange designs were nearly all based on flanges having hubs of approximately uniform thickness. The advent of welding has changed this and the most commonly used construction involves a flange with a tapered hub which is butt-welded to a shell or pipe.

A number of different methods have been used for calculating the stress in a flange, which are reviewed later in this paper. The general observation can be made, however, that in each case they had limitations which confined their use to certain types or ranges of flange cross section.

Extensive interest in the subject dates back to about 1927 when the Taylor-Waters formulas were presented before the A.S.M.E. (1).[5] These formulas had been based upon, and checked by, actual deflection tests conducted by J. Hall Taylor in 1924 and 1925. This method of calculating the stress in a flange has been the one most widely used since that time for the reason that it was substantiated by test data and was reasonably accurate over a wide range.

Flange design became a subject of extensive discussion and the methods of approaching and handling the problem of practical design were numerous. This resulted in the appointment of a joint committee composed of representatives of the A.S.M.E. Boiler Code Committee, the Joint A.P.I.-A.S.M.E. Pressure Vessel Committee and American Standards Association Committee B16E. In 1934 this committee drafted a set of rules (2) which set up a uniform procedure covering all important phases of the design, and represented the first known effort to introduce a rational stress analysis into the commerical design of flanged connections. This committee is continuing its work in an effort to improve these rules and recently it has had the additional assistance of the Heat Exchanger Institute.

One of the most important actions of this committee was a recognition of the importance of the longitudinal bending stress in the hub. Prior to the publication of these rules most designs had simply checked the tangential stress at the inner diameter of the flange and had ignored the possibility of the hub stress being the critical factor. The formula for the hub stress appeared in the Taylor-Waters paper (1) of 1927 but was not generally used.

Because of the conditions mentioned, the authors wish to present in this paper a condensed discussion of the problem of flange

---

[1] Associate Professor of Mechanical Engineering, Yale School of Engineering, Yale University. Mem. A.S.M.E. Professor Waters has been engaged since 1914 in the teaching of engineering subjects in the field of machine design and applied mechanics, with the exception of one year in the Ordnance Department, U.S.A., where he served under the Chief Ordnance Officer, A.E.F., in maintenance and construction work. For the past 10 years he has been a consultant on various problems of stress analysis in connection with the design of pressure vessels.

[2] Home Office Engineer, The Travelers Indemnity Company. Jun. A.S.M.E. After receiving an M.E. degree from Stevens Institute of Technology in 1927, Mr. Wesstrom spent five years with the M. W. Kellogg Company in research in the design of pressure equipment. In 1933 he entered the services of the Lummus Company as a designer and inspector. Since 1935 he has been employed in the engineering and inspection division of the Travelers Indemnity Company. He is active on several committees of the A.S.M.E., is chairman of the Boiler Code Subcommittee on Special Design, and is chairman of the A.S.M.E. Special Committee on Rules for Bolted Flanged Connections.

[3] Mechanical Engineer, M. W. Kellogg Company. Mem. A.S.M.E. Mr. Rossheim attended the University of South Carolina as an undergraduate in civil engineering, and later entered the United States Naval Academy. He was graduated in 1920 as an Ensign in the United States Navy, from which grade he resigned in 1923. After serving in the employ of several manufacturers of boilers and tanks, he became a member of the engineering staff of the M. W. Kellogg Company in 1927. He is a member of the A.S.M.E. Boiler Code Subcommittee on Special Design and other engineering committees.

[4] District Manager, Taylor Forge & Pipe Works. Mem. A.S.M.E. Mr. Williams was graduated with a B.S. degree from Yale University in 1925, and since that time has been connected with the Taylor Forge & Pipe Works. He is a member of the A.S.M.E. Boiler Code Subcommittee on Special Design, and also a member of several other engineering committees on pressure-vessel design.

[5] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Power Division for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until June 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

stresses and their calculation. The various methods that have been used are summarized with a brief analysis of each, and finally formulas are presented that are believed to give accurate results over a wide range.

Review of Earlier Work

Brief comments on some of the more important developments in the calculation of flange stresses will serve as a background for this paper.

Perhaps the earliest method of calculation to receive wide attention was the so-called "*Locomotive*" method, (3) generally credited to the late Dr. A. D. Risteen. The section *abcdefg* in Fig. 1 is assumed to rotate counterclockwise, but without distortion. The final equation is in effect the conventional flexure formula, the external moment being the total bolt moment per radian angle and the section modulus being that taken about the axis X-X' through the center of gravity O. For ring flanges this gives the tangential stress on either face, and for hubbed flanges it gives the tangential stress at the free end of the hub.

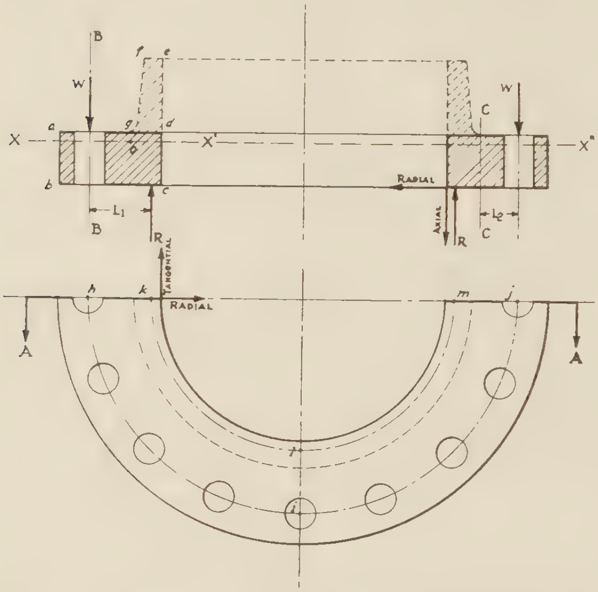


Fig. 1 Illustrations of Earlier Methods of Calculating Stress in a Bolted Flange

Crocker and Sanford developed a method (1, 4) whereby the flange is analyzed as a beam, in which bending about the neutral axis X-X'' takes place on the section A-A, and the external loads are one half the bolt load W and one half the reaction R, each concentrated at the center of gravity of their respective half-circles *hij* and *klm*. (The location of the bolt-load circle, however, was assumed tangent to the inner edge of the bolt holes, and not along the bolt circle as shown in Fig. 1.) This method likewise gives the tangential stress on either face of a ring, or at the free end of the hub.

Den Hartog (4) showed by vector analysis that although the *Locomotive* and Crocker-Sanford methods are derived in different ways, they are fundamentally identical.

A method devised by Tanner for ring flanges, and discussed by Waters and Taylor (1), is to assume the ring to be fixed at the section B-B around the bolt circle and to be equivalent to a cantilever beam of length L_1 with the "concentrated" load R uniformly distributed across a width equal to the circumference of the ring. This method gives the radial stress assumed to be present at section B-B. In the application of the method, Tanner took account of the tangential stresses by using suitable factors derived from experiments on rings of the proportions in which he was interested. The Tanner method was modified by Crocker (1, 4) for application to hubbed flanges (and presumably adaptable to ring flanges also) by assuming the fixed section to be the weakest section C-C in the ring at the base of the hub, with the load W "concentrated" at the distance L_2 at the free end and distributed along the bolt-loading circle. This likewise results in a calculation of the radial stress assumed to exist, in this case at section C-C.

None of the foregoing methods took into account all the conditions present in the flange under load, and so the Waters and Taylor paper in 1927 (1) based on a combination of the flat plate and the elastically supported beam theories, was probably the first instance in which the stress conditions in a flange in the three principal directions—tangential, radial, and axial—were explored with the object of determining the location and magnitude of the maximum stress. Formulas were included for the deflection of the ring, and the calculated deflections were compared with those actually obtained in several series of tests, the data of which were also reported. Because in flange proportions considered at that time the tangential stress in the ring at the inside diameter was the controlling factor, the formulas for stresses elsewhere in the flange were generally overlooked by designers.

The Waters-Taylor paper evoked extensive discussion (4) in the course of which Timoshenko presented an analysis for both ring flanges and hubbed flanges, including a method of dealing with hubs shorter than the so-called "critical" length. Most of these formulas can be found also in his work on "Strength of Materials" (5).

In 1931 Holmberg and Axelson wrote a paper (6) in which they used the flat-plate theory in developing formulas for stresses in loose-ring flanges and in flanges made integral with the wall of a pressure vessel or pipe.

In a series of articles recently published (7), Jasper, Gregersen, and Zoellner discussed further the formulas of Timoshenko, and Holmberg and Axelson. They also made an outstanding contribution to the subject by presenting the results of an extensive series of tests on plaster-of-paris models. Some of the data obtained were used in developing an analysis of the stresses in hubbed flanges having a large circular fillet at the junction of hub and ring.

When the rules for flanges in the A.S.M.E. and the A.P.I.-A.S.M.E. Unfired Pressure Vessel Codes (2) were first published in 1934, the wide range of their application made it necessary to use formulas based on a rational and complete theory, and because the Waters-Taylor equations met this requirement and had been checked by experiment, they were adopted, with auxiliary charts to simplify the calculations. The radial-stress formula was omitted, however, because it was not believed that it would be the critical factor in any practical design.

Several years of experience with the A.S.M.E. rules and the rapid development of large-size equipment for high pressures and temperatures have indicated the need for a revamping of these formulas. The influence of shearing forces at the junction of hub and ring was not included in their derivation, and this effect is important in many instances. The formulas are inconvenient to handle because they are based on the mean diameter and thickness of the hub; also, other assumptions on which they are based lead to difficulties. The method of handling hubs of nonuniform thickness, such as tapered hubs and large circular fillets, has proved unsatisfactory and it is believed does not give proper credit for reinforcement provided by such designs, where

a small amount of metal is so distributed as to result in greatly increased strength.

In the sections that follow the authors develop a method of flange-stress calculation, which it is believed will be easier to handle than the previous form of the formulas, and which is accurate over the complete range of practical design covering hubs of either uniform or tapered section.

Basis of the Present Study

The formulas presented in this paper can be applied to the circular flanges of bolted joints under pressure, such as flanges on heat exchangers, condensers, vulcanizers, and piping, when the flanges are free to deflect under the action of the bolt pull. This includes all types of flange facing where the gasket or contacting flange surfaces are entirely within the bolt circle, and excludes all cases where there is any contact outside of the bolt circle, as in a full-face gasket.

It is assumed that the flange is made of a homogeneous material having stable elastic properties and that these properties obtain under the conditions of loading assumed in the design. It is beyond the scope of this paper to discuss what occurs when the material becomes plastic. However, the general statement may be offered that when using these formulas to design steel flanges for high-temperature service, creep or progressive plastic deformation need not be taken into account if the design is such that the calculated stresses do not exceed the values at which creep will have an appreciable effect. In other words, the design should be based on the conditions obtaining in service after relaxation of the bolts and flanges is practically complete, using an appropriate safety factor.

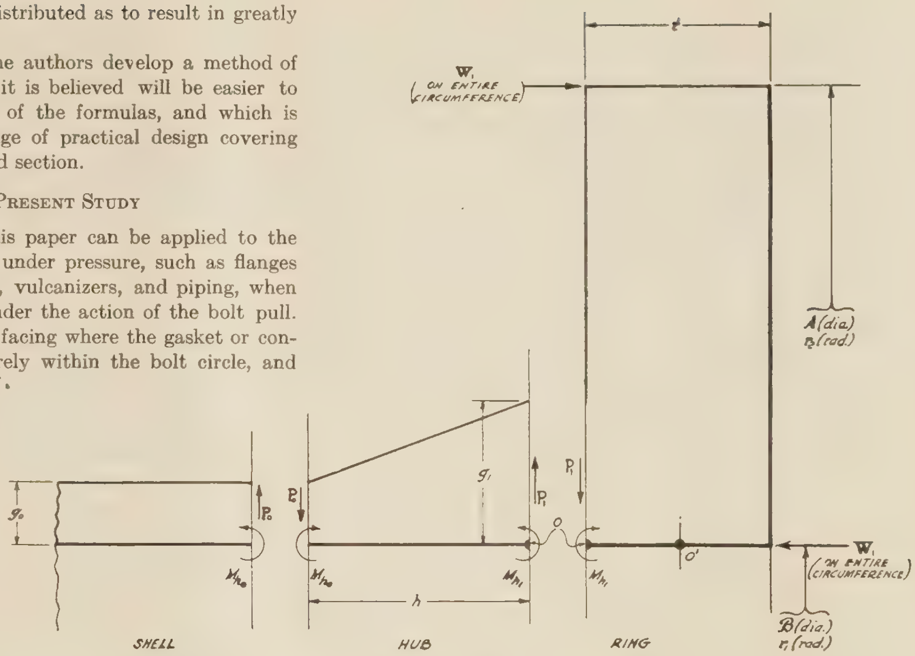


FIG. 3 ANALYSIS OF FORCES AND MOMENTS IN A TAPERED-HUB FLANGE

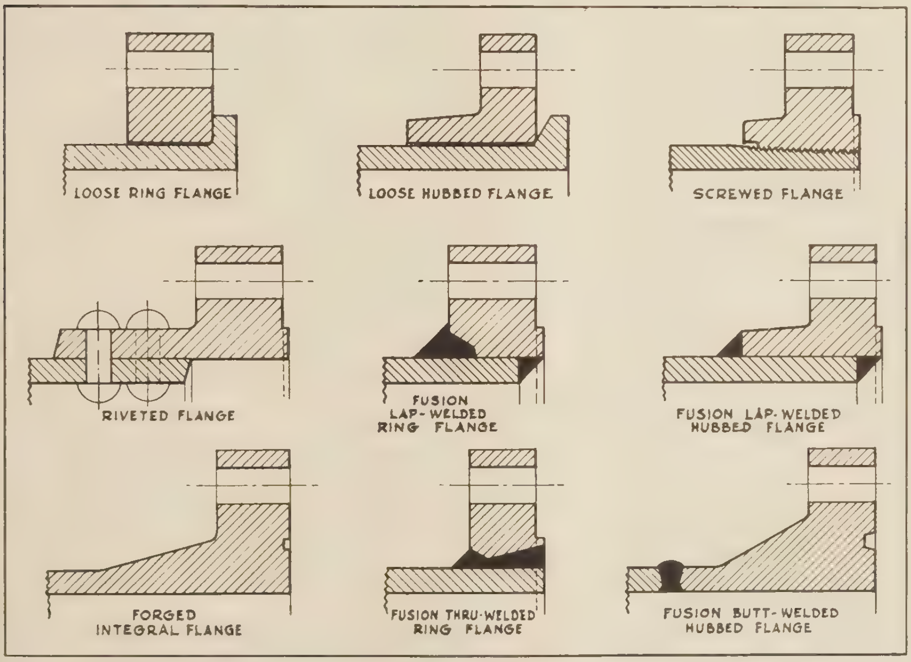


FIG. 2 SOME TYPES OF FLANGES TO WHICH THE AUTHORS' FORMULAS ARE APPLICABLE

It is not the purpose in this paper to deal with the probable stresses set up in the bolts on tightening them, or with the gasket or contact pressure required either to seal the contact surfaces or to maintain pressure tightness. These are separate items in the general subject of flange design and can be considered independently of the study of stresses in the flange under any given bolt load. It is assumed therefore that the bolt load has been determined, and this is used as a starting point.

It is also assumed that the lever arm of the bolt load has been determined. Most flange designs involve a compound lever arm, and a method, not theoretically exact but sufficiently approximate for practical purposes, for calculating compound lever arms may be found in Par. UA-20 of the A.S.M.E. Unfired Pressure Vessel Code or Par. W-317 of the Joint A.P.I.-A.S.M.E. Unfired Pressure Vessel Code (2).

The further assumption is made that for practical purposes the effect of the external moment on the flange, equal to the product of the bolt load and the lever arm, is the same in all cases, regardless of the location of the bolt circle and of the forces balancing the bolt load. This assumption may appear rash, but studies have been made that indicate it is practically true for ring flanges without hubs, and it is reasonable to suppose that

the same would obtain for hubbed flanges. The equations in the paper by Holmberg and Axelson (6) enable a study of the effect of applying the external loads at various diameters of a ring flange, and a detailed analysis of these equations has shown that the points of application can be varied over wide limits without affecting the results to any practical extent.

It should be noted here that the formulas presented herein are applicable to flanges without limit as to diameter, pressure, and temperature, and aside from the restriction as to type of flange facing noted previously, to flanges of all types. Some of these types are illustrated in Fig. 2, in which obviously the various forms of flange facing may be interchanged. Thus the formulas may be applied to loose flanges, with or without hubs, screwed flanges and flanges attached by riveted or welded lap joints, and integral flanges and flanges made integral by through welding a ring or butt welding a hub. In the Unfired Pressure Vessel Code (2) screwed flanges are considered as loose flanges because the shell or pipe offers very little, if any, resistance to the deflection of the flange. Flanges riveted and welded by means of lap joints are also considered as loose flanges. This results in a heavier flange, which is desirable in order to keep the unknown tension stresses on the rivets and fillet welds at a reasonable minimum.

The following analysis considers the general case of a tapered-hub flange, in the course of which a loose-ring flange, a loose flange with hub, and either a loose or integral flange with hub of uniform thickness are shown to be special cases of the general one.

Analysis of Stress Distribution

The tapered-hub flange may be subdivided into three portions, which will hereafter be termed the ring, hub, and shell, as shown in Fig. 3. Each portion may then be studied as an independent unit, with undetermined boundary conditions (displacement, rotation, moment, shear) at the junction surfaces. When the portions are assembled, each of these boundary conditions on one side of any junction surface is identically equal to a corresponding condition on the opposite side; in addition, certain conditions are known at the free boundaries of the assembled flange. Hence, sufficient relations exist for the evaluation of all boundary conditions in terms of the external loading, the dimensions of the flange, and the elastic constants of the material. From the mathematical standpoint, the problem is then completely solved; practically, it remains to investigate certain stress distributions and, if possible, establish simplified formulas, so that the labor of checking critical conditions in existing designs, or determining the proportions of new designs, may be lightened as much as possible.

The analysis may be greatly simplified by making the following assumptions:

1 Due to axial symmetry, the complete flange may be replaced by a unit sector, i.e., a sector whose plane faces have the form of Fig. 3 assembled, and include an angle of $1/r_1$.

2 The loading consists of (*a*) internal hydrostatic pressure acting radially on the bore of the flange and, through an assumed closure, in an axial direction as well; and (*b*) a moment acting on the ring, so distributed that it may be replaced by an equivalent couple applied at the inside and outside diameter of the ring.

3 Stretching of the middle surface of the ring, due to application of the ring moment, is negligible.

4 Dishing, or rotation, of the ring is small, so that the two load systems and their elastic effects are linearly related; and the complete problem may be solved by superposition.

5 When the ring moment is the only external load in action, point O shown in Fig. 3 has negligible displacement.

6 The hub and shell may be treated as membranes subject to tension and bending, and the radius to the middle surface may in general be used interchangeably with the inside radius r_1 shown in Fig. 3.

The following nomenclature is used throughout; in addition, the design formulas employ a notation, explained later, wherein the effort has been made to retain correspondence with present Boiler Code usage, as far as possible. In Fig. 3, where many of these symbols are indicated, it should be noted that forces and moments are shown in the direction which is taken as positive in this paper.

Nomenclature

A = outside diameter of ring, in.
a = lever arm, which when multiplied by the total bolt load W gives the total moment loading on the ring, in.
B = inside diameter of ring, hub, and shell, in.
c_n = constant of integration
D = flexural modulus of ring $= \dfrac{Et^3}{12(1-\nu^2)}$, in-lb
E = Young's modulus, lb per sq in.
g_0 = shell thickness, in.
g_1 = maximum hub thickness, in.
g = intermediate hub thickness, in.
h = hub length, in.
K = A/B
M_h = moment on a unit sector of hub, at any point, lb. Subscripts 0 and 1 refer to this moment at the small and large ends of the hub, respectively
M_r = radial moment at any cylindrical section of the ring, per unit circumference of the section, lb. Subscripts 1 and 2 refer to this moment at the inside and outside diameters of the ring, respectively
M_t = tangential moment at any point on a radial section of the ring per unit radius, lb. Subscripts 1 and 2 same as for M_r
P = shear on a unit sector of hub, at any point, lb per in. Subscripts 0 and 1 same as for M_h
p = hydrostatic pressure, lb per sq in.
Q = shear on a cylindrical section of the ring, per unit circumference of the section, lb per in.
r_1 = inside radius of ring, hub, and shell, in.
r_2 = outside radius of ring, in.
r = radius to any point in ring, in.
t = ring thickness, in.
W = total bolt load, lb
W_1 = equivalent bolt load, or total force applied at the outside diameter of the ring, and (oppositely) at the inside diameter of the ring, which multiplied by the radial breadth of the ring equals the total moment loading on the ring, lb
w = nondimensional radial displacement of hub or shell at any point, $= y/r_1$
x = axial distance along hub or shell, measured from junction surface between them, and positively in direction toward ring, in.
y = radial displacement of hub or shell at any point, in. (positive away from axis)
z = axial displacement of ring at any radius, in. (positive toward hub)
α = taper factor for hub $= (g_1 - g_0)/g_0$
β = shell modulus $= \sqrt[4]{3(1-\nu^2)/r_1^2g_0^2}$
θ = rotation of element of junction surface between hub and ring
κ = hub modulus $= 12(1-\nu^2)\, h^4/r_1^2g_0^2$

ν = Poisson's ratio; assumed value in design formulas is 0.3

ξ = nondimensional axial distance along hub = x/h

Tapered-Hub Flange Without Hydrostatic Pressure (8)

The loading and dimensions for the ring are indicated in Fig. 3. According to the Poisson-Kirchoff theory, the deflection of a flat plate with axial symmetry and no distributed load is given in polar coordinates by

$$\left(\frac{d^2}{dr^2} + \frac{1}{r}\frac{d}{dr}\right)\left(\frac{d^2}{dr^2} + \frac{1}{r}\frac{d}{dr}\right)z = 0 \qquad [1]$$

By solving this equation and differentiating the expression for z the appropriate number of times, equations for M_r, M_t, and Q are obtained. The complete solution obviously has four integration constants; only three boundary conditions are known so that, to eliminate all four constants, it is necessary to express a relation between two elastic conditions determined by the solution of Equation [1]. The most convenient relation, in so far as the subsequent analysis is concerned, is between M_{r1} and θ; it may be expressed by the equation

$$M_{r1} = -\frac{K^2 - 1}{\frac{1+\nu}{1-\nu}K^2 + 1}\left((1+\nu)\frac{2D}{B}\theta + \frac{W_1}{2\pi}\left[\frac{1}{2} + \frac{(1+\nu)}{(1-\nu)}\frac{(K^2)}{(K^2-1)}\log_e K\right]\right) \qquad [2]$$

Also

$$M_{t1} = -\frac{K^2+1}{K^2-1}M_{r1} - \frac{W_1}{2\pi}\left[\frac{1-\nu}{2} + \frac{(1+\nu)K^2}{K^2-1}\log_e K\right] \qquad [2a]$$

The three known boundary conditions which serve in the derivation of Equation [2] are

$$\left.\begin{aligned} z_1 &= 0 \\ M_{r2} &= 0 \\ Q &= -W_1/2\pi r \end{aligned}\right\} \qquad [3]$$

The hub loading is also shown in Fig. 3. The stresses and deformations are the same as those for a beam with varying section on an elastic foundation, if we consider a strip of the hub having unit circumferential dimension. Whether this dimension be measured at the middle, inside or outside surface is relatively unimportant; in this discussion, to preserve conformity with the ring analysis, the measurement is taken at the inside surface. Then the radial displacement at any point is given by

$$\frac{d^2}{dx^2}\left(g^3\frac{d^2y}{dx^2}\right) + \frac{12\,(1-\nu^2)\,g}{r_1^2}\,y = 0 \qquad [4]$$

For convenience, this may be written in nondimensional form as

$$\frac{d^2}{d\xi^2}\left[(1+\alpha\xi)^3\frac{d^2w}{d\xi^2}\right] + \kappa\,(1+\alpha\xi)\,w = 0 \qquad [4a]$$

by the substitutions defined in the nomenclature. It should be noted that the ratio $h^4/r_1^2g_0^2$, which is the essential part of κ, plays, with α, the most important rôle in the strength of the hub.

When g is variable, an exact solution is obtainable in terms of Bessel functions (9). In the present development, a close approximation is obtained by the strain-energy method with three parameters (a_1, a_2, a_3) which are so related that, if a_1 is used alone, a first approximation is obtained and all boundary conditions are satisfied; if a_1 and a_2 are used, a second approximation is obtained with all boundary conditions satisfied; and similarly for a_1, a_2, and a_3, used together (10). With regard to the boundary conditions, it may be remarked that here again they are four in number, since we are dealing with a fourth-order equation. They may be taken as: The radial displacement at the large end, moment at the large end, moment at the small end, and shear at the small end, in which cases the first is known (zero) and the remaining three are, for the present, unknown. In harmony with the nondimensional notation used in Equation [4a], these three unknown conditions may be replaced by the three quantities A_0, A_1, and B_0, which represent respectively the dimensionless curvature $d^2w/d\xi^2$ at the small end of the hub, that at the large end of the hub, and the dimensionless curvature gradient at the small end of the hub. Then, as explained in the authors' complete report (8), w can be written as a polynomial in powers of ξ, with a_1, a_2, a_3, A_0, A_1, and B_0 appearing in the coefficients; and equations can be found which determine a_1, a_2, and a_3 in terms of A_0, A_1, and B_0 for any given κ and α (i.e., any given hub proportions) and make the total energy of the strained hub, with its loads, a minimum. Coincidentally, Equation [4a] is approximately satisfied. This step is tantamount to solving Equation [4a] for w in terms of three unknown constants of integration, the fourth being zero ($w_1 = 0$). From the result, it is possible to compute slopes, moments, and shears by successive differentiation.

The shell has constant thickness g_0 and extends indefinitely from the hub. Using the same elastic theory as for the hub, two of the constants of integration vanish, and

$$y = e^{\beta x}\,(c_5 \sin \beta x + c_6 \cos \beta x) \qquad [5]$$

where $\beta = \frac{\sqrt[4]{\kappa/4}}{h}$, and x, it must be remembered, is now negative. Here again, the elastic conditions of higher order, such as slope and moment, are obtained by successive differentiation.

The analysis of the three separate parts of the flange is now complete, but there are five unknown constants in the equations, and these must either be evaluated or eliminated before numerical results can be obtained that will be consistent for the flange as a whole. On opposite sides of the shell-hub interface, the displacements, slopes, moments and shears are mutually identical; therefore, four equations exist whereby c_5, c_6, A_0, and B_0 may be expressed in terms of A_1. Having taken this step, it is then possible to express the slope θ, moment M_{h1} and shear P_1 at the large end of the hub, in terms solely of A_1. Finally, since $M_{h1} - 1/2P_1t = M_{r1}$, the quantities θ, M_{h1} and P_1 may all be substituted in Equation [2] and the latter then solved for A_1, giving the equation

$$A_1 = -\frac{2(1-\nu^2)\,h^2}{Eg_1^3r_1}MX \qquad [6]$$

where M and X are defined following Equation [10]. The resulting relation is the key to the derivation of the design formulas which are presented in a later paragraph.

The mathematical articulation of the three parts of the flange, as just outlined, involves an excessively large amount of computation whenever a numerical problem is to be solved. However, by grouping all terms in the final formula for A_1 which contain the parameters a_1, a_2, a_3 and constants A_0 and B_0 into two factors F and V, the first of which is proportional to P_1/A_1 and the second to θ/A_1, and plotting curves of F and V with α and κ (or their equivalents in hub dimensions) as arguments, a moderate amount of systematic computation in the preparation of the charts is substituted for many hours of labor on individual, unrelated design problems. The F and V factors appear in the design formulas, and are plotted in Figs. 4 and 5. In one case they apply to the integral type of flange that has just been ana-

lyzed; in the other, they are for loose flanges, where $A_0 = B_0 = 0$. In either event, they include the case of the uniform-hub-thickness flange, where $\alpha = 0$.

With regard to the shear force P_1 which enters into the determination of A_1, it should be noted that, theoretically at least, it can be determined either by differentiating w three times or integrating it once. Actually, due to the approximate nature of the strain-energy method, the two results are never identical. It is reasonable to suppose, however, that a single integration would introduce a smaller error than three successive differentia-

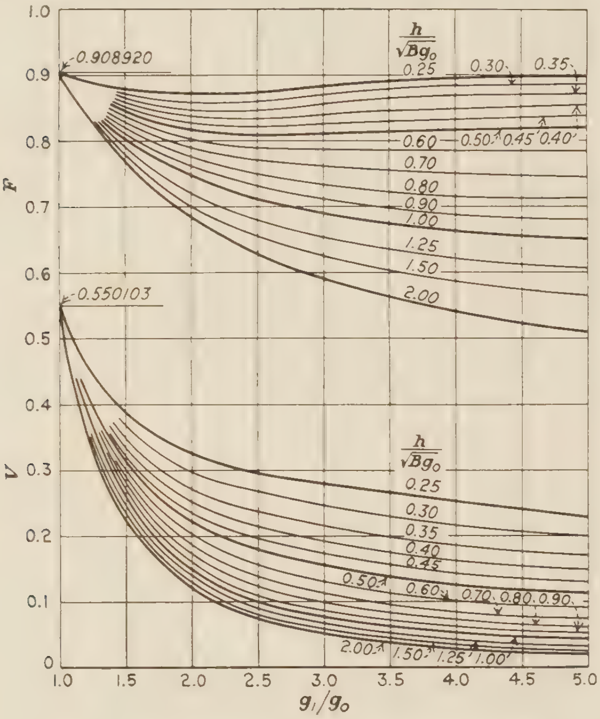


Fig. 4 Values of F and V for an Integral Flange

tions, and comparison of numerical solutions by the precise and strain-energy methods bears out this assumption. The authors have accordingly used the following expression for P_1 in the detailed mathematical development:

$$P_1 = \frac{E}{r_1^2} \int_0^h gy dx + P_0 \qquad [7]$$

Development of Design Formulas

For design and inspection purposes, a detailed analysis of the elastic conditions in all parts of the flange is superfluous, and the requisite data for information and guidance should be consolidated into a few usable formulas for stresses that may possibly be critical. Such formulas would be expected to cover conventional practice, or conservative extensions beyond present conventional design, but always with the reservation that new designs of more radical proportions might possess critical sections that would only come to light through the detailed analysis. All evidence indicates that for a flange with straight hub, the critical stresses are the radial and hoop stresses at the inside diameter of the ring, and the axial hub stress at the surface of junction with the ring. When the hub tapers in the manner assumed in this paper, the same critical stresses may be expected with the exception that, when the angle of taper increases beyond a certain limit, relative to the other hub proportions, the hub becomes so much more rigid than the shell that the location of the critical axial stress in the hub may be displaced from the large toward the small end or even into the shell. The question of the location and magnitude of this critical stress is of the first importance, and a careful study of stress distribution was made for the entire range of hub proportions covered in the charts for F and V, shown in Figs. 4 and 5, to determine under what circumstances a correction factor should be applied to the stress at the large end of the hub, so as to obtain the true maximum stress. It was found that the maximum axial stress always occurred either at one end of the hub or the other; consequently, it is a simple matter to compute its value by using, for the hub moment, either M_{h1} or M_{h0}, according to the location of the critical section. This has been done in design formula [8], where the factor f has been introduced to make the appropriate correction, if any, in the stress. One exceptional condition arises: When α and κ are such that the bending stresses at both ends of the hub are approximately equal, slight oscillations in the values of stress at points along the hub make f somewhat greater than unity. This has been taken account of, in preparing the chart for f shown in Fig. 6, by an adjustment of the lower end of the curves in the vicinity of $f = 1$.

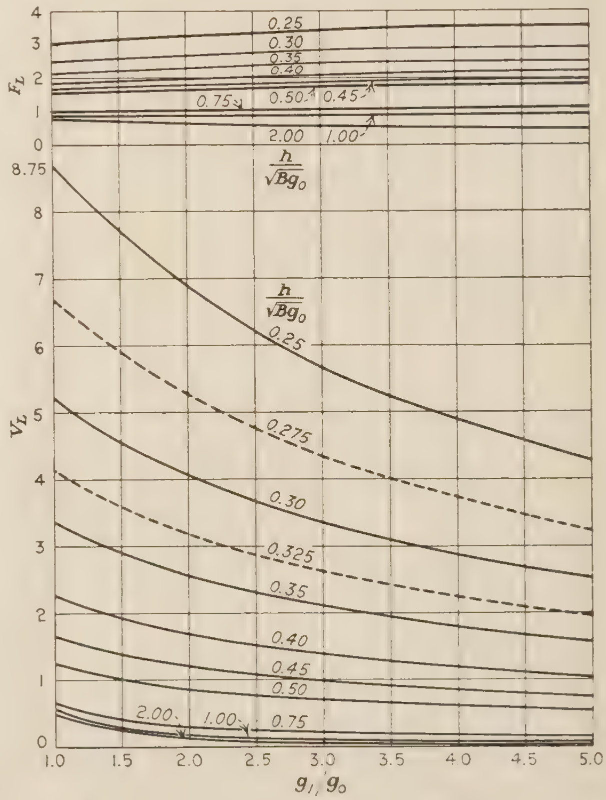


Fig. 5 Values of F and V for a Loose Flange

(Subscript L denotes values of F and V are for a loose flange.)

In the case of loose flanges, an investigation of hubs over the ranges of proportions considered in this paper brought out the fact that the maximum bending stress always occurs at the large end of the hub, consequently $f = 1$ for loose flanges.

In accordance with the foregoing principle, three design formulas have been derived from Equation [6] for computing the maximum axial stress in the hub (or shell), the radial stress in

the ring at its inside diameter, and the corresponding hoop or tangential stress. The first of these results directly from substitution of Equation [6] in

$$M_{h1} = \left[\frac{EI}{12(1-\nu^2)}\,\frac{d^2y}{dx^2}\right]_1 = \frac{Eg_1{}^3 r_1 A_1}{12(1-\nu^2)\,h^2}$$

dividing by the section modulus $g_1{}^2/6$ according to the simple flexure theory, and multiplying by the factor f, which is the ratio of the maximum axial bending stress to the axial bending stress at the junction of the hub and ring. The second results from substitution of M_{h1} and P_1 in the equation $M_{r1} = M_{h1} - \frac{1}{2} P_1 t$, followed by the usual conversion from moment to extreme fiber stress, to which is added the radial stress due to the shear P_1 assumed to be uniformly distributed through the ring thickness. The third is obtained exactly as the second with the added use of Equation [2a]. In this third formula, the hoop stress due to P_1 is added. Finally, it is assumed that $\nu = 0.3$ and the

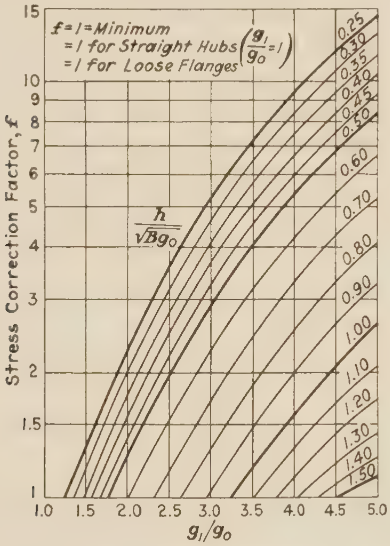


Fig. 6 Values of Stress-Correction Factor f

logarithmic base is changed from e to 10 to facilitate slide-rule computation. Then, using the special design notation, these stresses are

$$S_H = fMX/g_1{}^2 \ldots\ldots [8]$$

$$S_R = \left[1 + 1.33F\,\frac{t/g_0}{\sqrt{B/g_0}}\right] MX/t^2 \ldots\ldots [9]$$

$$S_T = (MY/t^2) - ZS_R \ldots\ldots [10]$$

where S_H = maximum axial stress at outer surface of hub or shell, lb per sq in.

S_R = radial stress at the inside diameter of the ring, in ring face next to hub, lb per sq in.

S_T = hoop stress coincident with S_R, lb per sq in.

M = Wa/B

f = ratio of S_H to axial stress at outer surface of hub where hub joins flange = stress-correction factor. Values are plotted in Fig. 6 for g_1/g_0 from 1 to 5, and $h/\sqrt{(Bg_0)}$ from 0.25 to 1.50

F, V = plotted in Figs. 4 and 5 for the same range as in Fig. 6

$$X = \frac{1}{\dfrac{1}{T}\left(1 + \dfrac{t/g_0}{\sqrt{B/g_0}}F\right) + \dfrac{V}{U}\,\dfrac{(t/g_0)^3}{\sqrt{B/g_0}}}$$

$$T = \frac{3K^2\left(1 + 2\,\dfrac{1+\nu}{1-\nu}\cdot 2.3026\log_{10}K\right) - 3}{\pi(K-1)\left(1 + \dfrac{1+\nu}{1-\nu}K^2\right)}$$

$$U = \frac{3K^2\left(1 + 2\,\dfrac{1+\nu}{1-\nu}\cdot 2.3026\log_{10}K\right) - 3}{\pi(1+\nu)(K^2-1)(K-1)}$$

$$Y = \frac{1}{K-1}\left[\frac{3}{\pi}(1-\nu) + \frac{6}{\pi}(1+\nu)\,\frac{K^2}{K^2-1}\cdot 2.3026\log_{10}K\right]$$

$$Z = \frac{K^2+1}{K^2-1}$$

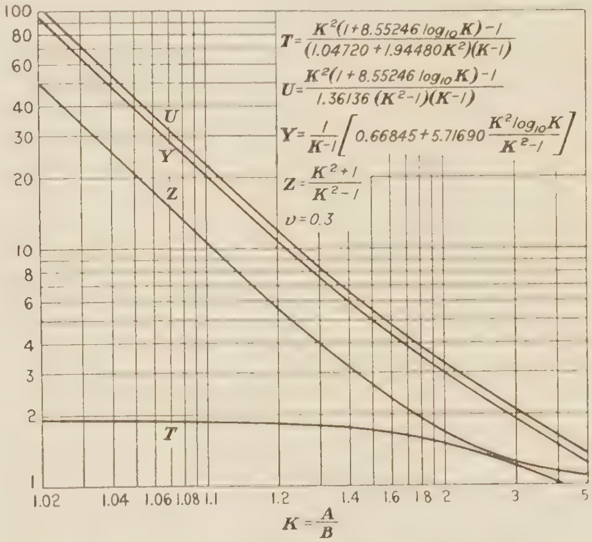


Fig. 7 Values of T, U, Y, and Z When $\nu = 0.3$

Functions of K are plotted in Fig. 7. It should be noted that in the case of loose-ring flanges, there is no hub, consequently S_H and S_R as given by Equations [8] and [9] equal zero.

Tapered-Hub Flange With Hydrostatic Pressure and No Bolt Load

There is an apparent paradox in the title of this section, in that the externally applied forces are not balanced in the axial direction. Actually, the axial pull on the shell may be thought of as balanced by a virtual pull on the contact face of the ring, upon which is superposed a couple of sufficient magnitude to give a resultant pressure on the contact face; and since the stress effects of this couple are completely determined by the methods given earlier in this paper under "Analysis of Stress Distribution," the hydrostatic end force on the shell and the virtual pull on the ring face are the only axial loads that need be considered here. It must further be observed that point O shown in Fig. 3, can no longer be considered as fixed, since the hydrostatic pressure tends to stretch both hub and ring, whereas in the method given earlier in this paper under "Analysis of Stress Distribution" the shearing action at the interface tends to stretch one part and shrink the

other, so that the net effect can, with some justification, be disregarded. With these preliminaries, a stress analysis will now be outlined.

The radial force acting outward on the ring at its inside diameter is $p - P_1/t$ per unit area, and the radial displacement of point O' shown in Fig. 3 may be found by the usual thick-cylinder analysis. The displacement y_1 of point O is greater than this by $-{}^1/_2\ \theta t$; this gives a relation between y_1, P_1, and θ. Secondly, the rotation between the hub and the ring at O is found by letting $W_1 = 0$ in Equation [2] and solving for θ; this gives a relation between θ and M_{r1}, or θ, M_{h1}, and P_1. The hub and shell equations are identical with Equations [4] and [5] except that the right-hand members have a constant term proportional to p/E which gives, in the solution for y, the membrane expansion due to p with discontinuity effects neglected. All told, there are six constants of integration (four in the solution of the hub equation and two in that for the shell); and since there are four identical elastic conditions at the shell-hub interface and two independent relations established for the ring, the necessary and sufficient equations exist for evaluating them.

Unfortunately, the computations for a single problem are extremely laborious; however, it would be possible to derive a set of F and V values analogous to those presented previously in this paper, in which the combined rotation and expansion of the ring are taken into account, and which could be used in simplified formulas like Equations [8], [9], and [10], but with M replaced by p, to compute the first and second peaks of stress caused by the internal pressure.

It may also be suggested that, since the discontinuity stresses due to pressure are apt to be much smaller than those due to bolt pull, it is not necessary to compute them with any great precision. Suppose, for a first approximation, that the tapered hub and shell are replaced by a shell of constant thickness g_0, and that the ring is wide enough to prevent expansion of this assumed hub at its constrained end. If there is no rotation of the ring, the existence of internal pressure causes a large positive moment at the junction with the hub, which is of no consequence as it is counteracted by a negative moment at the same location due to bolt pull; furthermore, the first peak of negative moment due to internal pressure is so small as to be inconsequential. On the other hand, if we permit the end of the assumed hub to rotate freely, at the same time constraining it against expansion, we obtain a zero moment at the junction of hub and ring, and a negative moment at some distance from this point, which is in general of the order of magnitude of the negative peak of moment that occurs in the actual hub-shell combination under pressure from within. The extreme fiber stress due to this moment may be combined with the stress due to the hydrostatic end force, and with the maximum bending stress in the hub due to bolt pull, if the latter occurs at the small end of the hub, to get an approximate value of the maximum longitudinal stress due to both internal pressure and bolt pull. If the maximum longitudinal hub stress due to bolt pull alone occurs at the large end of the hub, it is considered unlikely that a much greater longitudinal stress, due to combined bolt pull and internal pressure, occurs at any point whatever.

The mathematical expression for the maximum longitudinal stress in the hub, caused by internal pressure, is greatly simplified by this approximation. Using

$$y = e^{\beta x}\,(c_9 \sin \beta x + c_{10} \cos \beta x) + \left(1 - \frac{\nu}{2}\right) \frac{r_1^2 p}{g_0 E}$$

and its first and second derivatives, and specifying that $y = M_h = 0$ when $x = 0$, it is found that the integration constants become

$$c_9 = 0 \text{ and } c_{10} = -\left(1 - \frac{\nu}{2}\right) \frac{r_1^2 p}{g_0 E}$$

Substituting these in the equation for the moment and its first derivative, the maximum moment in the hypothetical hub, due to pressure, is found to occur at a distance $x = -\pi/4\beta$ from the back of the ring, and its value is

$$M_h = -\left(1 - \frac{\nu}{2}\right) \frac{pe^{-\pi/4}}{(2\sqrt{2})\ \beta^2}$$

The corresponding longitudinal tensile stress in the outer surface of the hub, assuming $\nu = 0.3$ is

$$S_1 \approx 0.5\ r_1\ p/g_0$$

In other words, the maximum stress in the outer fibers of the hub, due to bending caused by internal pressure, is of the same magnitude as the direct tensile stress in the shell due to the hydrostatic end force.

Illustrative Problems

A few illustrative problems are given as an aid to a clear understanding of the charts and design formulas. In the second and third problems, a calculation of the bending stresses along the hub and shell has been made, showing the separate effects of bolt load and hydrostatic pressure. This requires the use of formulas and methods which are only outlined in the present paper, but are given in complete detail in the authors' report, previously referred to (8).

Example 1. Given an integral flange with the following dimensions: $A = 44^1/_8$ in., $B = 36^5/_8$ in., $t = 2^{15}/_{16}$ in., $g_0 = 1$ in., $g_1 = 1^1/_2$ in., $h = 3^1/_8$ in. Find the critical stresses S_H, S_R, S_T, assuming that the bolting is such as to give a ring moment of 402,000 in-lb.

The design factors are: $M = 10976$, $K = 1.2048$, $g_1/g_0 = 1.5$, $h/\sqrt{Bg_0} = 0.5164$, $t/g_0 = 2.9375$, $\sqrt{B/g_0} = 6.05186$. From Fig. 4, $F = 0.847$, $V = 0.310$, and entering Fig. 7 with K, it is found that $T = 1.835$, $U = 11.91$, $Y = 10.4$, $Z = 5.60$. According to Fig. 6, $f = 1$. By calculation, $X = 1.139$, and the three stresses that may be critical are, in round numbers: $S_H = 5500$ lb per sq in., $S_R = 2200$ lb per sq in., and $S_T = 700$ lb per sq in.

This flange is designed to carry an internal pressure of 75 lb per sq in., which gives a longitudinal membrane stress of only 460 lb per sq in. at the large end of the hub, negligible in comparison with S_H. At the small end of the hub the longitudinal membrane stress is 700 lb per sq in., which, as previously stated, may be taken as a rough indication of the maximum bending stress that may be expected from the internal pressure.

If we compare the stress conditions in this flange as just computed with those in an identical flange not secured to a shell, i.e., a loose flange with hub, we find that F and V have new values. These, as obtained from Fig. 5 are $F_L = 1.52$ and $V_L = 0.98$. This changes X to 0.773, and the three stresses become $S_H = 3770$ lb per sq in., $S_R = 1950$ lb per sq in., and $S_T = 2290$ lb per sq in. If the hub of the loose flange is made progressively shorter, it will be found that S_H and S_R approach zero, while S_T becomes the critical stress and approaches its maximum value of 13,230 lb per sq in.

Example 2. A filter shell flange has the following dimensions: $A = 127$ in., $B = 120^1/_4$ in., $t = 2^{15}/_{16}$ in., $g_0 = {}^5/_8$ in., $g_1 = 1^1/_8$ in., $h = 3^1/_8$ in., bolt-circle diameter $= 124^1/_2$ in., outside diameter of gasket = 123 in., inside diameter of gasket $= 121^1/_4$ in. Thirty-six $1^1/_2$-in. bolts are used, with an allowable stress of 20,000 lb per sq in. Using a slight modification of the method specified in the A.S.M.E. Code for Unfired Pressure Vessels for computing the effective loading on the ring, in accordance with the practice of certain designers, the equivalent ring moment Wa is assumed equal to 903,000 in-lb.

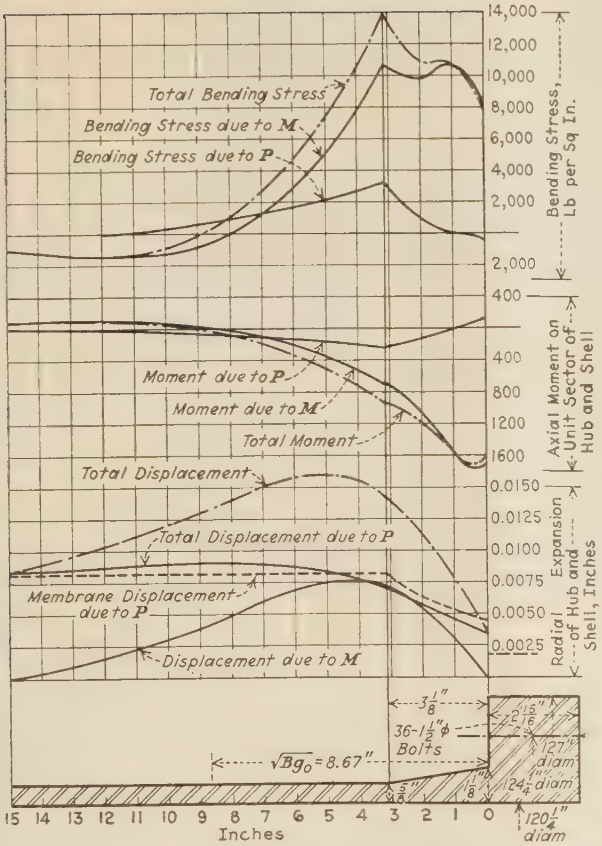


Fig. 8 Graphical Results of Examples 2 and 3

The various factors in the design formulas are then as follows: $K = 1.0561$, $g_1/g_0 = 1.8$, $h/\sqrt{Bg_0} = 0.3605$, $F = 0.852$, $V = 0.293$, $T = 1.90$, $U = 39.0$, $Y = 35.2551$, $Z = 18.3295$, $t/g_0 = 4.7$, $\sqrt{B/g_0} = 13.8708$, $X = 1.3427$, $M = 7509.36$, and $f = 1.4$. The foregoing factors have been computed either directly or from plotted values of a_1/A_1, a_2/A_1, etc., since it was desired to include a detailed analysis of hub stress in this and the following problem, for which accurate values of the design factors are essential. Stresses that may be critical are, in round numbers: S_H = 11,000 lb per sq in. (at small end of hub), S_R = 1600 lb per sq in., and S_T = 750 lb per sq in. It is quite obvious that in this particular flange the ring stresses are negligible.

Using the detailed stress analysis in the authors' complete report (8), the displacement, bending moment, and bending stress in the hub and shell have been computed for selected points, and the corresponding curves are shown in Fig. 8. These curves bring out clearly the stiffening effect of the tapered hub, the effect of the taper in shifting the maximum moment and bending stress away from the large end of the hub, and the small value of the shell as a strengthening element after a certain length has been reached. No curves are shown for the ring, since the ring stresses are not critical and the ring proportions are such that it rotates with practically no change of shape.

Example 3. The flange of example 2 is subjected to an internal pressure of 50 lb per sq in. Again using the formulas in the complete report, curves of displacement, moment and bending stress are shown in Fig. 8 for the effect of hydrostatic pressure with bolt pull absent. The dashed line indicates the membrane expansion of the three elements of the flange, treated as independent members without discontinuity stresses. The slope of the solid displacement curve at the junction of hub and ring illustrates the rotation of the ring due to hydrostatic pressure alone, in which respect the behavior differs markedly from that of a cylindrical vessel with reinforcing ring at a distance from its end. The moment at the large end of the hub is reduced, and the maximum occurs not at that point but at the second peak, where its sign reverses so that the bending stresses due to bolt pull and hydrostatic pressure are additive.

When the effects of bolt pull and internal pressure are combined, it is found that the latter adds considerably over 25 per cent to the bending stress caused by the former; thus, illustrating the importance of an investigation of pressure effects when the two components of bending stress have additive maxima. It should also be noted that the total expansion reaches a maximum of about 200 per cent of the membrane expansion alone. However, since the membrane hoop stress in the shell, figured by the customary simple rule, is somewhat less than 5000 lb per sq in., the actual maximum hoop stress is not excessive when compared with the maximum bending stress. Specifically, the total stresses at the junction of shell and hub are as follows, using Hooke's law for two dimensions:

Axial stress, outer surface = longitudinal membrane stress + bending stress = 16,575 lb per sq in.

Axial stress, inner surface = longitudinal membrane stress — bending stress = —11,765 lb per sq in.

Hoop stress, outer surface = (E × total hoop strain) + ν (axial stress in outer surface) = 12,068 lb per sq in.

Hoop stress, inner surface = (E × total hoop strain) + ν (axial stress in inner surface) = 3565 lb per sq in.

BIBLIOGRAPHY

1 "The Strength of Pipe Flanges," by E. O. Waters and J. H. Taylor, *Mechanical Engineering*, vol. 49, Mid-May, 1927, pp. 531–542.

2 A.S.M.E. Unfired Pressure Vessel Code, Pars. UA-16 to UA-22, inclusive, 1935. Also: API-ASME Code for Unfired Pressure Vessels for Petroleum Liquids and Gases, Pars. W-317 and R-317, The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y., 1936.

3 "The Flanged Mouth-Piece Rings of Vulcanizers and Similar Vessels," *The Locomotive*, vol. 25, July, 1905, pp. 177–203.

4 "Methods of Determining the Strength of Pipe Flanges," discussion of paper by Waters and Taylor (1), *Mechanical Engineering*, vol. 49, December, 1927, pp. 1340–1347.

5 "Strength of Materials," by S. Timoshenko, D. Van Nostrand Company, Inc., New York, N. Y., part 2, article 29, 1930.

6 "Analysis of Stresses in Circular Plates and Rings," by E. O. Holmberg and K. Axelson, Trans. A.S.M.E., vol. 54, 1932, paper APM-54-2, pp. 13–28.

7 "Strength and Design of Covers and Flanges for Pressure Vessels and Piping," by T. M. Jasper, H. Gregersen, and A. M. Zoellner, *Heating, Piping, and Air Conditioning*, vol. 8, November and December, 1936, pp. 605–608 and pp. 672–674, respectively; vol. 9, 1937, January, February, March, pp. 43–47, pp. 109–112, and pp. 174–176, 178, respectively.

8 "Development of General Formulas for Bolted Flanges," Taylor Forge and Pipe Works, Chicago, Ill. The detailed mathematical derivations given in this report are omitted from the present paper for brevity.

9 "Statik und Dynamik der Schalen," by W. Flügge, Julius Springer, Berlin, 1934, p. 132.

10 "Berechnung von Behältern," by Th. Pöschl, Julius Springer, Berlin, 1926, p. 139.

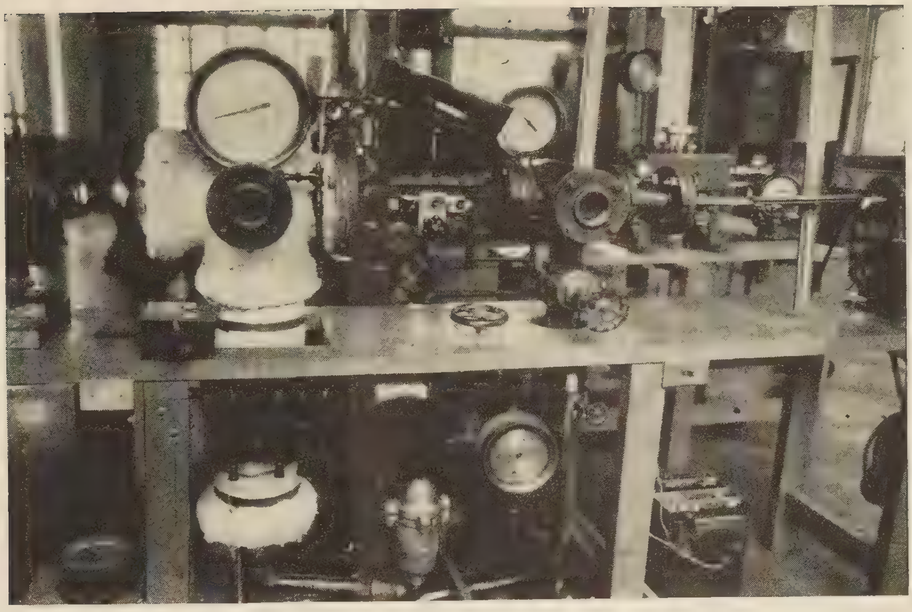


Fig. 1 The Apparatus Used in the Experiments

The Condensation of Flowing Steam
Part I—Condensation in Diverging Nozzles

By J. I. YELLOTT,[1] HOBOKEN, N. J., and C. K. HOLLAND,[2] NEW YORK, N. Y.

The authors discuss the apparatus and method used in determining the point of condensation in diverging nozzles. The discussion is restricted to nozzles with very short throats and with angles of divergence greater than 2 deg. As a primary result of the work described, the authors locate the Wilson line for continuously expanding steam at the 4.5 per cent moisture line on the Mollier diagram. Condensation points and sizes of steam droplets are discussed for various pressure and temperature conditions before expansion and for various back pressures.

Nomenclature

THE FOLLOWING symbols are used in this paper. Special notations are explained as the necessity arises:

A = area, sq ft
a = area, sq in.
d = liquid density, lb per cu ft
h = enthalpy, Btu per lb
k = exponent of isentropic expansion for wet steam
m = area ratio, a_2/a_1
p = abs pressure, lb per sq in.
P = abs pressure, lb per sq ft
r = droplet radius, ft
R = gas constant, ft-lb per deg per lb
S = supersaturation ratio = p_c/p_s
t = temperature, F
T = abs temperature, F
v = velocity, fps
V = specific volume, cu ft per lb
x = exponent of isentropic expansion for steam expanding after condensation
β = pressure ratio, p_2/p_1
γ = exponent of isentropic expansion for superheated steam
σ = surface tension, lb per ft
Δh_i = isentropic change in enthalpy, Btu per lb

[1] Assistant Professor of Mechanical Engineering, Stevens Institute of Technology. Jun. A.S.M.E. Professor Yellott received the degree of Bachelor of Engineering in 1931 from Johns Hopkins University after which he returned to the University for two years of graduate work under Prof. A. G. Christie. He received his M.M.E. degree from Johns Hopkins University in 1933 and then became instructor in mechanical engineering at the University of Rochester. He joined the faculty of Stevens Institute in 1934 where in September, 1936, he was advanced to his present grade.

[2] Mechanical Engineering Division, Phoenix Engineering Corp. Jun. A.S.M.E. Mr. Holland was graduated from Stevens Institute of Technology in 1934 with an M.E. degree and received his master's degree in 1936. From June, 1934, to June, 1936, he served as instructor in mechanical engineering at Stevens Institute. The data presented in this paper were the basis of his thesis for his M.S. degree.

Contributed by the Fuels and Steam Power Division for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until June 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

δh = loss due to supersaturation, Btu per lb
δt = undercooling, $t_s - t_{ss}$, F

The following subscripts are used:

e = equilibrium expansion or condition
sat = saturated condition
ss = supersaturated condition
c = condensation condition
1 = initial condition before the expansion
2 = final condition after the expansion

Introduction

It has long been known that in rapid expansions steam does not condense when the saturated condition is reached. Instead it continues to expand as in the superheated region, thus becoming supersaturated or undercooled. This condition persists until the steam reaches some lower pressure at which condensation suddenly takes place in the form of a vast number of extremely minute droplets. This phenomenon has been of interest to physicists since the classic researches of C. T. R. Wilson (1),[3] whose cloud chamber is widely used in the study of ionization problems. J. J. Thomson (2) analyzed the work of other important contributors to this field, among whom should be mentioned Aitken, Barus, von Helmholtz, and Sir William Thomson, later Lord Kelvin.

The late H. M. Martin suggested in 1918 (3) that this failure to condense might be of importance in the design of turbine nozzles. It was Martin (3, 4) who applied Wilson's name to the line on the Mollier diagram which marks the loci of the conditions at which condensation actually occurs. Stodola (5, 6) made a number of experiments in this field and originated the optical method which has been used by the authors in the present work. Vol. 2 of Stodola's monumental work on steam turbines contains a detailed discussion of many aspects of this problem. A different approach to the subject was made by Goodenough (7), in which he maintained that two-phase velocities were probably responsible for the peculiar flow coefficients found with wet steam.

[3] Numbers in parentheses refer to the Bibliography at the end of the paper.

In 1934 Yellott (8) published the results of work done at the Johns Hopkins University under the guidance of A. G. Christie. This work has since been carried forward by J. T. Rettaliata (9). Since 1934 an extensive series of tests has been performed; first at the University of Rochester by Yellott and Gridley, and later at Stevens Institute by the authors. The purpose of this work, part of the results of which are presented in this paper, was to check the accuracy of the original tests and to clarify certain points which were not thoroughly understood. It was soon discovered that an error in the original experimental methods had caused an incorrect location of the Wilson line. Improved apparatus also revealed a number of phenomena which did not appear in the original experiments.

The investigation of the general problem of the condensation of flowing steam is still under way, and it seems desirable to present at this time only the results of the work on diverging nozzles. This phase of the work has been subjected to repeated tests and the results are so consistent that they are considered by the authors to be reliable.

The condensation which occurs in converging nozzles has not yet been studied in sufficient detail to warrant publication of the results which have been obtained. It must suffice to say that condensation can occur in converging nozzles and it is usually accompanied by rapid growth of the droplets. Condensation can occur over a relatively wide range of steam conditions, and, as suggested by Rettaliata (9), a Wilson zone must therefore be introduced to replace the Wilson line.

The Experimental Work

Basis of the Experimental Work. When work was begun on this problem in 1931, it was found that with proper illumination the point of condensation in flowing steam could be seen clearly.

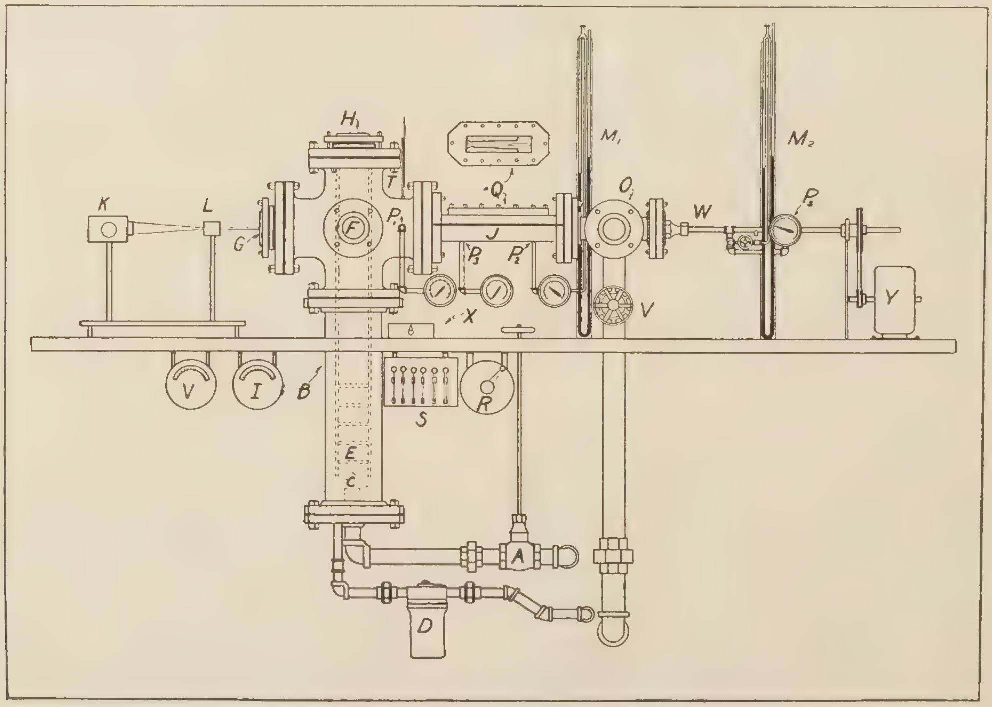


Fig. 2 Details of Steam-Flow Apparatus

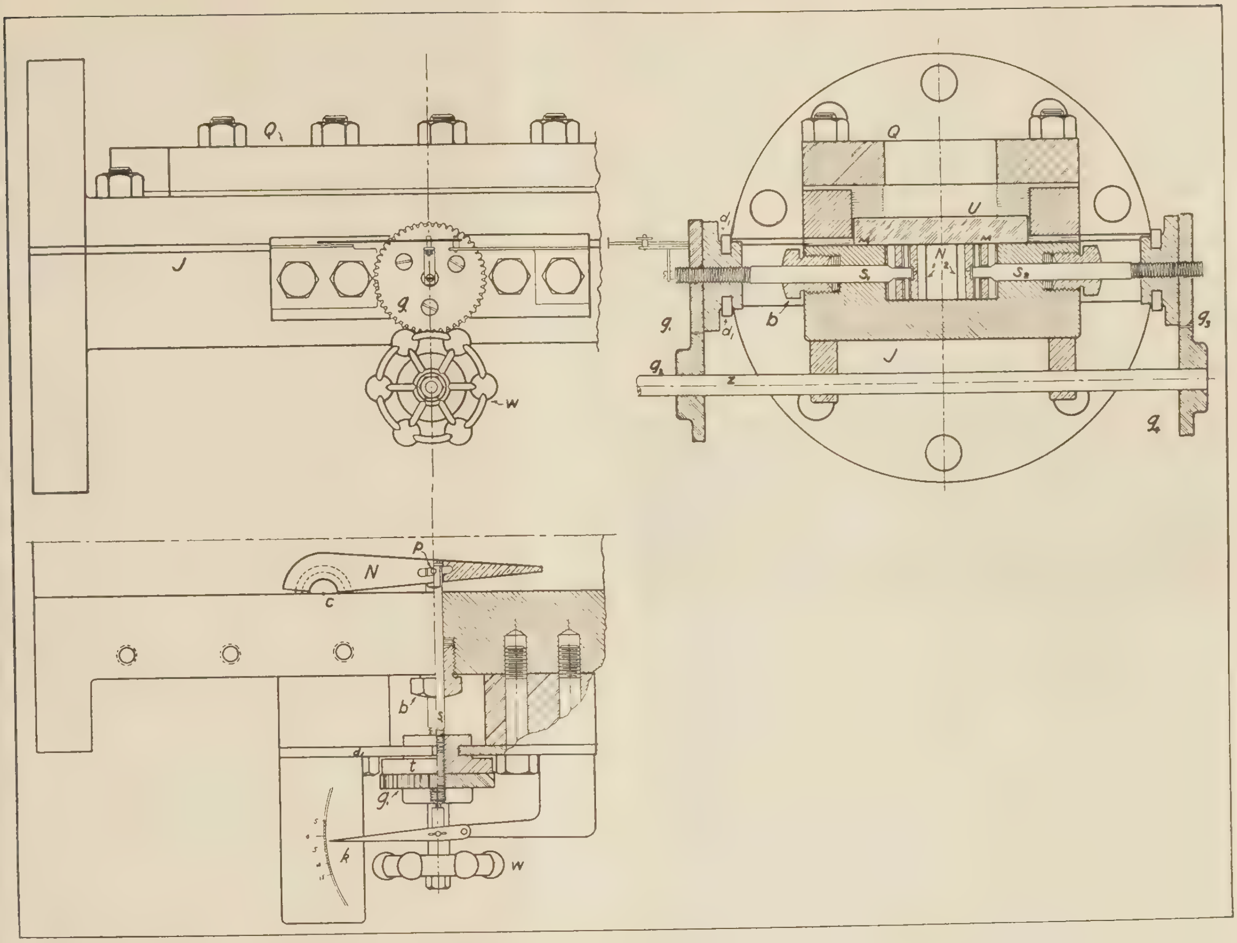


Fig. 3 Details of Nozzle Design

If a beam of intense light were passed axially along the nozzle, the light scattered by the droplets could be observed through a glass window in the top of the nozzle. This principle has been employed in all of the succeeding work, although the apparatus has been considerably improved and the experimental methods have been refined. The static pressure at the condensation point was determined by very small holes in a brass search tube which could be traversed along the axis of the nozzle. A sharp break was found to occur in the pressure-length curve at the point where condensation took place. Because of this fact, condensation points could be located even when the optical method was not employed.

It was noticed that the light scattered by the drops was blue in color and almost completely plane-polarized when observed from a direction normal to that of the incident light. The drops were thus shown to be far smaller than the wave length of the light which was scattered by them. This polarization was frequently used to assist in locating the point at which the condensation occurred. When condensation took place in larger drops or when originally small drops grew to larger size, the nature of the polarization changed.

Description of the Apparatus. The apparatus now being employed is shown in Fig. 1. It is quite similar to that used in the original work (8), but a number of important changes have been made. Referring to the sketch of the apparatus shown in Fig. 2, steam from the laboratory mains enters through a pressure regulator. A cooling jacket around the inlet pipe allows the steam to be thoroughly desuperheated if necessary. Further regulation is accomplished by the globe valve *A*, after which the steam passes into the 6-in. vertical pipe *B*. An inverted metal cone *C* is of some value in removing the larger drops of water which frequently accompany the incoming steam, but the smaller drops do not appear to be deterred by it. Drainage is accomplished by the steam trap *D*.

The electrical superheater *E*, consisting of five nichrome coils supported by porcelain insulators and steel rods, is capable of dissipating about 8 kw. It is controlled by the knife switches *S*, and the input is measured by the voltmeter *V* and the ammeter *I*. Power can be supplied either from the laboratory d-c line at 110 volts or from a small turbogenerator. The voltage supplied by the generator can be controlled by means of the field rheostat *R*, which permits close regulation of the steam temperature.

The steam then passes through the cross which is equipped with glass ports at *F* and *G*. Light from the carbon arc *K* is admitted through *G* and the entering steam can be examined through *F*. The leads from the superheater are brought out through insulated bolts in the top flange *H*. The temperature of the steam is measured by a precision-grade mercury-in-glass thermometer which is inserted in a mercury-filled thermometer well at *T*. This thermometer has been calibrated by the National Bureau of Standards and checked in place by the pressure-temperature relation for saturated steam. When the proper stem correction is applied,

the thermometer gives results which agree within 0.1 F with the saturation temperature when wet steam is passing through the apparatus.

The pressure is measured by a calibrated Bourdon gage or a mercury manometer connected to a $^1/_4$-in. pressure tap at P_1 in the side of the cross. The principal difference between the present apparatus and that used at the Johns Hopkins University (8) lies in the fact that for the earlier work the temperature was measured by a thermometer located at F while the pressure was measured from a $^1/_{32}$-in. tap in the bottom of the nozzle channel at P_3. It was thought at that time that the pressure drop, $p_1 - p_3$, through the entrance to the channel was negligible. This assumption was later found to be erroneous, and because of it the Wilson line as located in 1934 (8) was about 1 per cent too high.

The nozzles are located in the cast-iron channel J, which is shown in detail in Fig. 3. The channel, which is 2 in. wide, 1 in. deep, and 15 in. long, is located in the lower part of the nozzle assembly. The upper part of the assembly is bolted tightly to the lower part, and $^1/_8$-in. rubber-sheet packing is used to prevent leakage. The central portion of the top of the assembly is cut away to accommodate the glass plate U. The plate is a special high-temperature glass, $^5/_8$ in. thick. The glass bears directly on the scraped cast-iron surface MM, and is held down by the cover plate Q. Several thicknesses of sheet packing are used as a gasket between the cover plate and the glass, and leakage at this point is effectively prevented. The use of this double construction has eliminated the glass breakage which frequently occurred in the original apparatus.

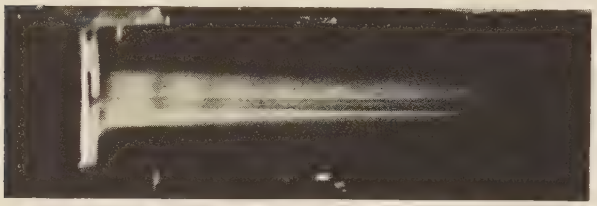


Fig. 4 Flow Through a Rounded-Approach Nozzle
(Steam conditions: p_1 = 60 lb per sq in. abs; t_1 = 306 F; and p_2 = 29 lb per sq in. abs.)

A number of different nozzles have been used in the work. Usually the nozzle is rectangular in cross section and is made by bolting appropriately shaped brass blocks to the walls of the channel. Round nozzles have been made by drilling holes in 1-in.-square steel stock and milling or turning out the superfluous material. Fig. 4 illustrates the flow from such a round nozzle with a rounded approach.

Recently interesting results have been obtained with a variable convergent divergent nozzle, the angle of divergence of which can be varied while the nozzle is being observed through the glass plate. This nozzle was designed by R. Z. Hague of Stevens Institute, class of 1937, and the details are shown in Fig. 3. The nozzle block N is made in two parts which are riveted together. This construction enables N to pivot about c as a center without serious leakage, while approximately the same entering conditions are preserved as the angle of divergence is varied. The block is caused to move by the pin p through the shaft s, which in turn is moved by the threaded member t. Lateral motion of t is prevented by the split collar d_1, and leakage along s is prevented by the packing in the stuffing box b. The gear g_1 fixed to t, is turned by the gear g_2, which is operated by a small hand wheel w. The shaft z transmits the same rotary motion to the gears g_3 and g_4. The other nozzle block N_2 is caused to move by the left-handed threads on the shaft s_2.

The angle of divergence is indicated by the graduations on the dial k and by numbers on the teeth of g_1. The dial was calibrated by means of accurate templates and checked trigonometrically with micrometer and gage-block measurements. The readings from g_1 bear an approximately linear relation to the angle of divergence, which makes possible adjustments which are accurate to within ± 5 min. The angle of divergence can be varied from +16 deg to —5 deg.

The clearance between the blocks N_1 and N_2 and the glass U is about 0.001 in., and the leakage through this space is unimportant. Due to a slight looseness of the pin p, the angle must always be read when the nozzle is being closed. Thus far no other difficulties have arisen with this device.

The back pressure is obtained by a $^1/_{32}$-in. tap at the bottom of the channel at P_2, shown in Fig. 2. This tap is connected by water-filled lines to a combination gage and to a 30-in. mercury manometer. The steam passes out of the apparatus through the side outlet tee O, and through the gate valve V to a condenser. A port mounted at O permits the steam to be observed as it leaves the apparatus.

Static pressures along the axis of the nozzle are obtained by the search-tube W, which is 0.125 in. in diameter. The four pressure taps on the tube are located in a plane perpendicular to the axis of the tube and are about 0.005 in. in diameter. The tube leads to a combination gage O_s, and a mercury manometer M_2. An indicator can also be mounted on the search tube and autographic traverses can be made with the assistance of the motor Y, which is controlled by the switch X. When full illumination of the channel is required the search tube can be reversed and mounted at port G.

The optical system which supplies the illumination consists of a clock-fed carbon arc K, a condensing lens, and a focusing lens L. A water cell is usually used when filters or polarizers are being employed. If the water cell is omitted, the heat from the beam is usually sufficient to prevent fogging of the port G through which the light is admitted. The sight glasses at the ports F, G, and P are pyrex disks, $^1/_2$ in. thick, mounted between $^1/_8$-in. rubber gaskets. The glasses must be cleaned at frequent intervals because of the impurities which accompany the steam. Cleaning can sometimes be accomplished by passing very wet steam through the apparatus.

Review of the Experimental Work. The work at Rochester in 1934 and at Stevens in 1935 was largely experimental in nature, for each new apparatus made visible a number of phenomena which were not observed with the earlier equipment. During 1935, attention was directed to the condensation of wet, saturated, and superheated steam in a typical convergent divergent nozzle. A large number of condensation-pressure measurements were made for initial pressures ranging from 20 to 100 lb per sq in. abs, and temperatures up to 395 F. The range of entropy was 1.62 to 1.767.

It was found at the University of Rochester that variation in the back pressure could play an important part in determining the type of condensation which occurs in diverging channels, and this problem has been investigated more fully.

The use of a sharp-edged orifice revealed the fact that changes in the vena contracta could be observed as the back pressure was reduced below the critical ratio, $p_2/p_1 = 0.55$. With such an orifice, the flow continues to increase as the back pressure is lowered, instead of becoming constant as does the flow from a rounded nozzle. Fig. 4 shows the flow from a rounded-entrance nozzle discharging at a velocity slightly greater than the velocity of sound. The standing pressure waves shown in this picture have been investigated by Prandtl (10) and Emden (11).

It was noticed in all of the work mentioned previously in this paper that back-pressure variations and alterations in the rate of expansion resulted in characteristic changes in the nature of

the condensation. The variable nozzle was therefore designed in order to permit complete control of all the factors involved in the problem. A precision potentiometer has been procured and work is now going forward on the problems of condensation in converging and slowly diverging streams. Correlated work is being done on the problem of measuring supersonic velocities by impact tubes in the hope that eventually velocity coefficients can be established for supersaturated expansions.

It is the purpose of this paper to present the results of the work on convergent divergent nozzles of the type to which, in honor of the inventor, the name "De Laval" is given. The discussion will be restricted to nozzles with very short throats and with angles of divergence greater than 2 deg. It is believed that within these relatively narrow limits the results presented here are reliable. The results should be of value to the designers of apparatus in which these types of nozzles are used, such as the reversing sections of marine turbines. Steam-jet air ejectors and steam-jet refrigerators also use nozzles of this type.

Results of Tests on De Laval Nozzles. The effect of variations in the initial conditions of the expanding steam upon condensation pressure and supersaturation was investigated by measuring the static pressure at the condensation point for a wide range of initial conditions. Most of the measurements were made with a nozzle similar to that shown at the top of Fig. 5. The angle of divergence of this nozzle is about 11 deg and the back pressure could not be reduced sufficiently to make the nozzle flow full at all times. Fig. 6 shows a series of flow illustrations taken with

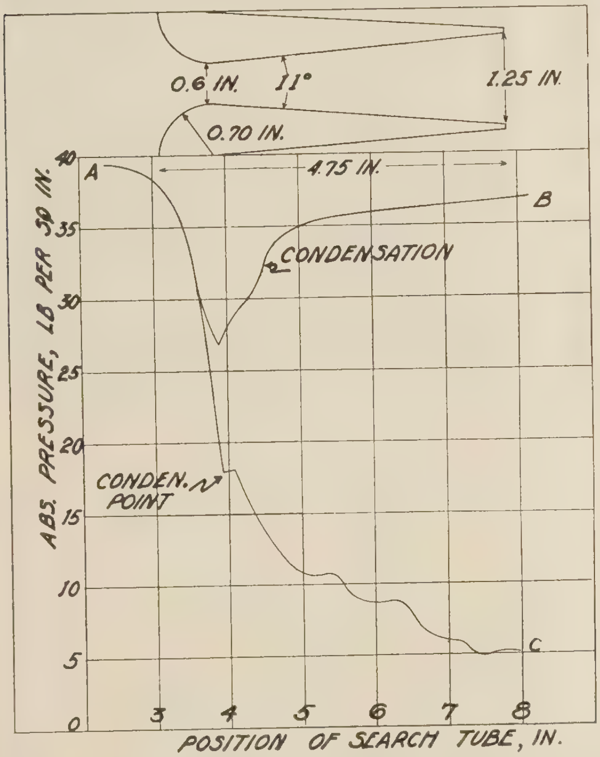


Fig. 5 Typical Pressure Traverse in a Divergent Nozzle
(Steam conditions: p_1 = 40 lb per sq in. abs; saturated; for curve AB, p_2 = 37 lb per sq in. abs; and for curve AC, p_2 = 6 lb per sq in. abs.)

the same initial pressure of 100 lb per sq in., and temperature of 371 F, but with the back pressure varying from 17 to 45 lb per sq in. abs. It will be noted that the flow breaks away from the side of the nozzle at different points, but the nature of the condensation is the same for all cases.

If the back pressure p_2 is raised to within a few pounds of the initial pressure p_1, there is a sharp drop in pressure to the throat of the nozzle and then a rapid recompression up to the back pressure, as shown by curve AB in Fig. 5. Under such conditions, if the steam were initially saturated or very slightly superheated, a slight condensation would occur as the pressure is rising. The point of origin of this condensation is difficult to detect, for the first scattered light is very faint. The term "preliminary condensation" was applied to this type in the earlier paper (8), to distinguish it from the "ultimate condensation" which occurs at the Wilson line.

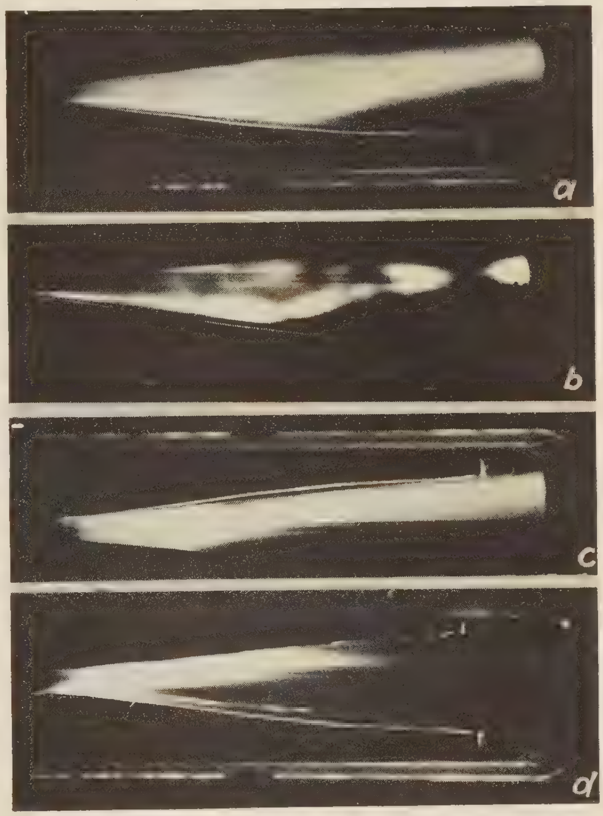


Fig. 6 Flow Through a Fixed Nozzle From an Initial Pressure of 100 Lb per Sq In., and an Initial Temperature of 371 F, but With Varying Back Pressures Illumination From Low Pressure End, Search Tube in Place
(Top: Back pressure = 18 lb per sq in. abs. Second: Conditions the same as for the top illustration but taken through a Polaroid disk to show photoelastic effect. Third: Back pressure = 26 lb per sq in. abs. Bottom: Back pressure = 45 lb per sq in. abs.)

Under the conditions which prevailed when the data for curve A-B, Fig. 5 were obtained, a faint trace of condensation was detected at the 4.5-in. point, about $^1/_2$ in. downstream from the throat. The first color to be seen was an indeterminate saffron, which was followed by violet, purple, green, and saffron again. These colors were visible only when the angle of observation was less than 90 deg to the incident light. If the angle of observation was greater than 90 deg, the entire nozzle seemed to be filled with a whitish-blue color. The scattered light was very slightly polarized at all angles of observation. These optical effects indicate that the droplets are of the same order of magnitude as the light waves which they scatter, from 1.3 to 2.3 $\times$ 10^{-6} ft. The variation in color along the length of the nozzle indicates that the drops are growing, which is natural because the pressure

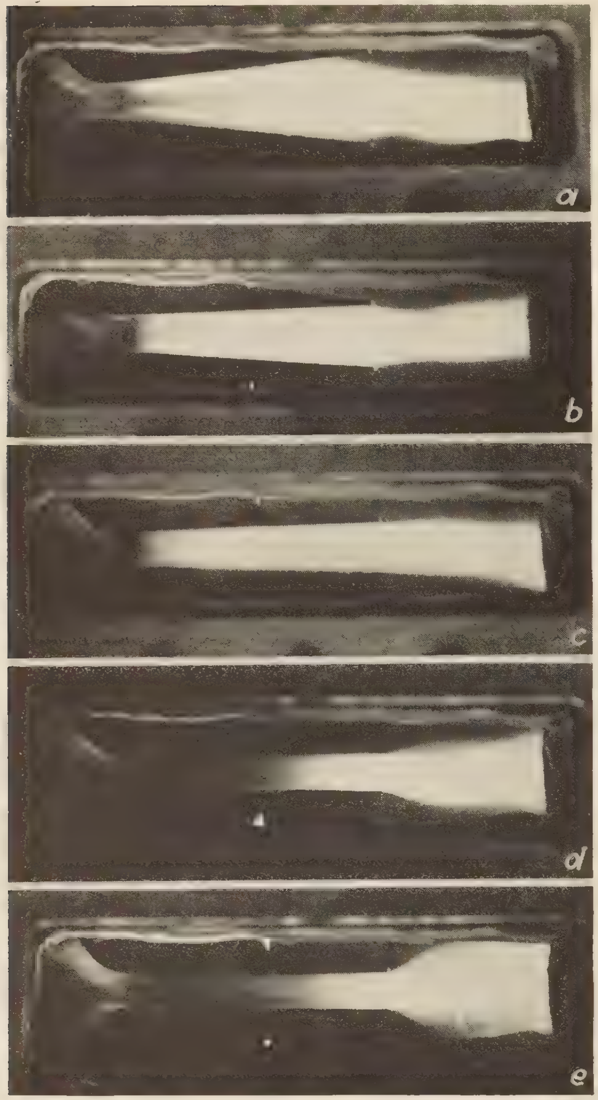


Fig. 7A Flow Through a Variable Nozzle From an Initial Condition of 40 Lb per Sq In. Abs, Saturated; Back Pressure Kept at 10 Lb per Sq In. Abs Except for Last Condition, When It Was Lowered to 7 Lb Abs

(a, Divergence angle set at 13 deg, nozzle overexpanding, steam breaks away from sides. b, Divergence angle 7 deg, overexpanding, Mach wave at exit. c, Divergence angle 4 deg, steam leaves without shock. d, Divergence angle 0 deg, preliminary condensation in nozzle, jet expands beyond exit. e, Divergence angle 0 deg back pressure lowered to 7 lb per sq in. abs. Steam expands to fill channel. Water drops entering with steam reveal eddies beyond exit.)

of the vapor is rising, and consequently the temperature is also increasing. The drops apparently form during the pressure rise, but their temperature does not increase rapidly and they are consequently cooler than the surrounding vapor. Thus, they are able to act as nuclei for further condensation.

If the steam becomes superheated by only a few degrees, the color disappears and the nozzle appears quite empty. When the steam is desuperheated, the pressures remaining constant, the same colors reappear. A small amount of initial moisture has no affect, but a large amount produces a confused picture in which the scattered light is lost.

Fig. 7A shows a series of photographs taken of the variable nozzle, in which the initial condition was held constant at 40 lb per sq in. abs, saturated. The back pressure was kept at 10 lb per sq in. abs except in e, when it was lowered to 7 lb. At an angle of divergence of 13 deg, a, the nozzle was overexpanding and the steam broke away from both sides. At 7 deg, b, the nozzle flowed full, but overexpansion was still present and a Mach wave was visible. This wave could be seen clearly with the eye, but difficulty was experienced in photographing it. Consequently the negative from which b was made was retouched slightly to make the wave stand out more clearly. When the angle was reduced to 4 deg, c, the exit area was approximately correct and the nozzle flowed full without shock. When the sides were made parallel, d, preliminary condensation appeared in the nozzle. Beyond the exit ultimate condensation occurred and the jet expanded but did not fill the channel. With the angle kept at 0 deg, e, the back pressure was reduced to 7 lb abs

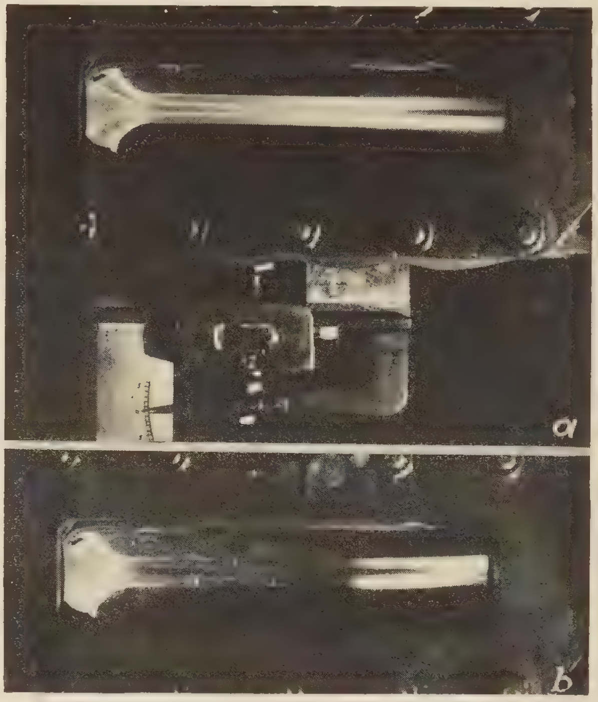


Fig. 7B Top View of Variable Nozzle, Illuminated From High Pressure End, Search Tube in Place

(a, p_1 = 40 lb per sq in. abs, wet; p_2 = 13 lb per sq in. abs; divergence angle set at 0 deg. Preliminary condensation in nozzle followed by ultimate condensation beyond exit. b, Steam conditions same as in a, except initial temperature raised to 285 F. Preliminary condensation absent, ultimate condensation beyond nozzle.)

and the jet expanded until it filled the entire channel. The water drops which were entering the nozzle with the incoming steam revealed an interesting double eddy beyond the nozzle. For the photographs in Fig. 7A the nozzle was illuminated from both the high- and low-pressure ends.

Fig. 7B shows two photographs of the variable nozzle in which the initial steam pressure was kept at 40 lb per sq in. abs while the angle of divergence was kept at 0 deg. The back pressure was 13 lb abs in both cases. In a, the entering steam was wet and preliminary condensation was occurring in the nozzle, with ultimate condensation taking place beyond the exit. In b, the steam temperature was raised to 285 F (18 F superheat) and the preliminary condensation disappeared. For these photographs the nozzle was illuminated from the high-pressure end only, the search tube being mounted on the low-pressure end.

The nuclei upon which the preliminary condensation was

occurring were probably ions, for a charged particle can grow as it follows a path of falling pressure, while an uncharged particle cannot (2). Condensation in nozzles with small angles of divergence is being studied at the present time, and it is hoped that the results will be available shortly.

The results of the condensation-pressure measurements for varying initial conditions are shown on the Mollier diagram in Fig. 8. These values were obtained by making a series of traverses along that portion of the nozzle in which condensation was occurring and noting the pressure at the point where the fog originated. A plot of the pressure against the position along the nozzle axis was also prepared for each test as in Fig. 5, curve *A-C*, and the location of the step in the pressure curve confirmed the visual observation.

By the use of the desuperheater mentioned previously, it was possible to observe the condensation of steam which was initially wet. In spite of the presence of such large quantities of moisture that the beam of arc light could scarcely penetrate to the nozzle, the condensation invariably took place in the same manner as with steam which was initially dry. The familiar blue color was present in the scattered light and the curved condensation surface, concave toward the higher pressure, was also evident. The stream lines of the incoming moisture were frequently visible on the glass top of the nozzle. By throttling the steam with the control valve, the moisture could readily be made to disappear, thus giving visual evidence in support of the theory of the throttling calorimeter. An explanation of the failure of the moisture already present to affect the condensation of new moisture probably lies in the fact that the drops are hotter than the expanding vapor. Hence, the drops are not able to serve as nuclei but will rather tend to evaporate.

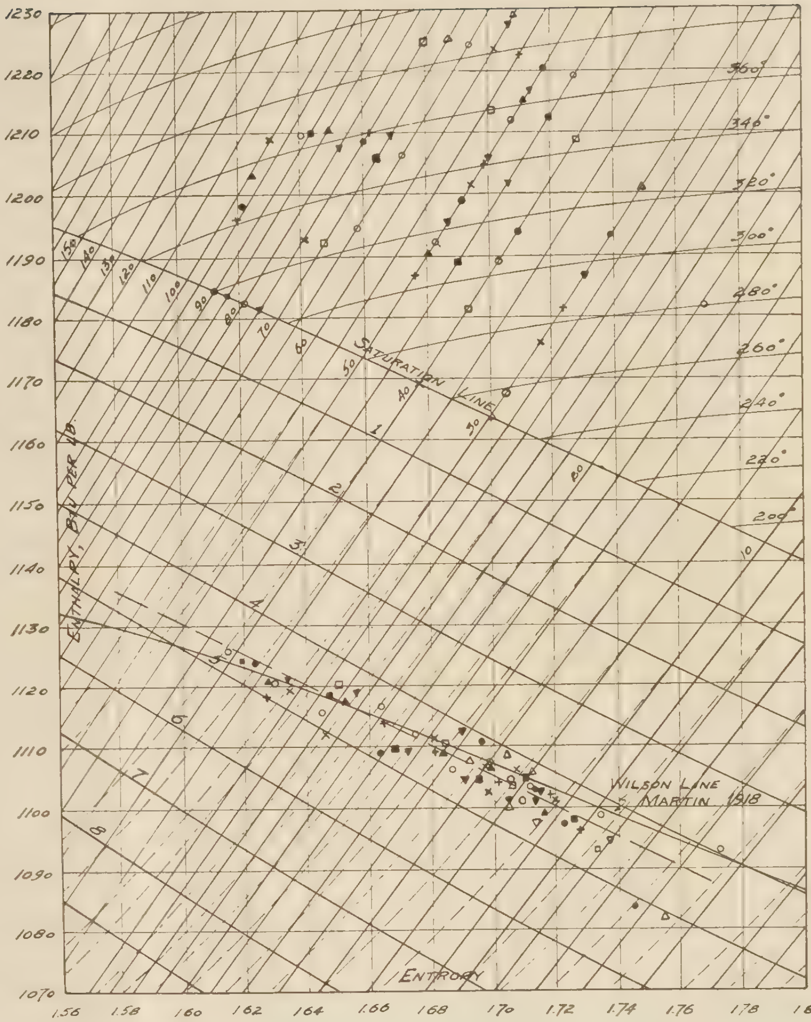


Fig. 8 Mollier Diagram Showing Experimental Results

It will be noticed from Fig. 8 that no initial conditions are shown below the saturation line. Although the entering steam may contain moisture, it behaves as if it were merely a mechanical mixture of saturated steam and drops of water. It is quite possible to have drops of water in an atmosphere of superheated steam, and the presence of water droplets in steam does not insure that the steam is saturated. Additional evidence is necessary, such as the agreement of the temperature of the steam with the saturation temperature at the prevailing pressure. It is probably impossible to measure temperatures in steam below the saturation temperature, because the measuring device will always provide a finite surface upon which condensation will occur.

The points in the superheated region in Fig. 8 were obtained with the aid of the electrical superheater. The points on the 30-lb and 40-lb lines were measured at Rochester while the other points were obtained at Stevens Institute. The agreement in the location of the condensation points would seem to eliminate any question as to possible peculiarities in the steam used in the tests.

The condensation points in Fig. 8 were plotted in the conventional manner shown in the elementary Mollier diagram, Fig. 9*a*. Isentropic expansion is assumed to exist along the axis of the nozzle from the initial condition p_1, t_1, until the condensation pressure p_c is reached at *c*. At this point condensation occurs and there is supposedly an isenthalpic change of condition, accompanied by an increase in entropy, to the equilibrium pressure at *c*. The condensation points, as shown, are plotted as the equilibrium pressures rather than the supersaturated pressures. If they are plotted as the supersaturated pressures, a special Mollier diagram with the supersaturated constant-pressure lines is necessary.

Further expansion takes place from p_e, and it can be seen that there is a loss of availability, δh, because of the increase in entropy which accompanies the condensation.

The procedure just discussed is open to question because it neglects the rise in pressure which has been observed to occur when condensation takes place. Keenan (13) has shown such a pressure rise must occur in a sudden condensation under the conditions which prevail in these nozzles. Likewise, in assuming that the temperature of the vapor rises completely to the saturation value for p_c, we overlook the fact that the droplets formed in the condensation are so small that according to Kelvin's law the vapor

about them is still supersaturated. Both of these questions will be considered later.

The results given in Fig. 8 reveal the important fact that rapid expansions starting on the same entropy line will result in condensation at virtually the same point. Thus, it seems probable

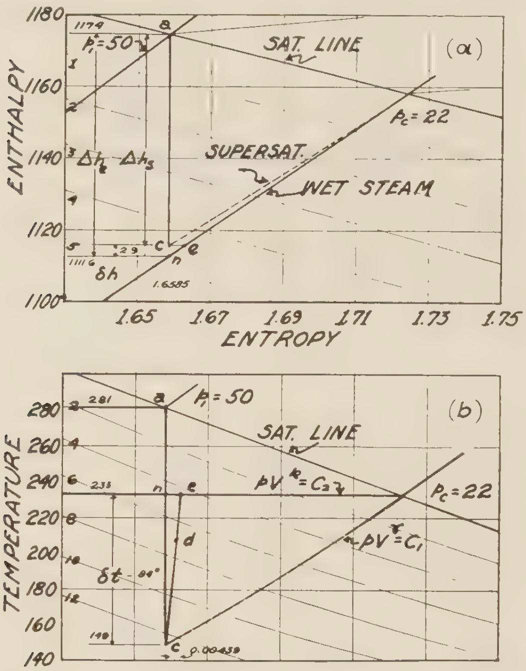


FIG. 9 CONDENSATION POINTS PLOTTED ON ELEMENTARY MOLLIER AND T-S DIAGRAMS

that condensation in such expansions depends only upon the supersaturation and not upon the velocity. For example, the two points on the 1.68-entropy line differed by 35 Btu in their initial enthalpy, but the condensation pressures for the two conditions were almost identical. The upper point, at 70 lb per sq in. abs and 387 F, gave a condensation pressure of about 17 lb per sq in. abs, while the velocity at the condensation point was about 2370 fps. The lower point on the same entropy line is at 50 lb per sq in. abs and 312 F, but the condensation pressure was again at about 17 lb per sq in. abs, although the velocity at the condensation point was about 1985 fps. A still lower point at approximately the same entropy was at the saturated condition of 40 lb per sq in., and this also yielded a condensation pressure of about 17 lb per sq in., with a velocity of about 1670 fps. This relatively wide variation in velocity has apparently had only a small effect, if any, on the condensation. In the same manner, steam with an initial condition of 54 lb per sq in. abs and 360 F, gave approximately the same condensation pressure as steam initially at 30 lb per sq in. saturated.

Since rapid expansions through a De Laval nozzle along any entropy line will result in condensation at the same pressure, regardless of the initial pressure and temperature, the results given in Fig. 8 can be replotted in the form of Fig. 10. This gives the condensation pressure as a function of the initial pressure for steam which is initially saturated. The data for this plot were taken from the dashed line on Fig. 8, which appears to be a fair representation of the experimental values. The scatter of the points is due largely to the difficulty of making accurate determinations of the condensation pressure.

It will be noted from Fig. 10 that the condensation pressure is almost a linear function of the initial pressure for the range along the saturation line which was covered in this work. Whether this relation holds for higher pressures will be learned from tests soon to be performed at Purdue University with a high-pressure apparatus.

Another useful relation is shown in Fig. 11, in which is plotted the ratio p_c/p_1 against p_1 for initially saturated steam. It is apparent that this ratio is always below the critical ratio of approximately 0.55, and consequently ultimate condensation always occurs in the diverging portion of the nozzle and at a velocity above that of sound.

The Wilson line shown in Fig. 8 is apparently the lower limit for supersaturated expansions, for at this condition condensation invariably occurs. In slow expansions, as in nozzles with long throats or small angles of divergence, preliminary condensation can occur at conditions above the Wilson line. The upper limit seems to be at about the 2 per cent moisture line on the Mollier diagram. Thus the Wilson zone, within which condensation

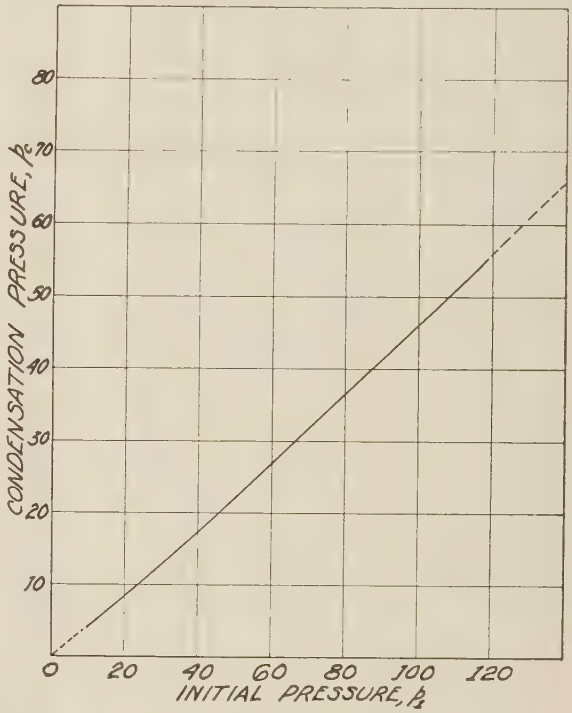


FIG. 10 CONDENSATION PRESSURE AS A FUNCTION OF INITIAL PRESSURE; STEAM INITIALLY SATURATED

must occur, is located between the 2 and 4.5 per cent moisture lines. It is worthy of notice that the Wilson line which Martin predicted from theoretical considerations (3) in 1918 is very close to that determined experimentally.

The supersaturation ratio which exists at various condensation temperatures is plotted against these temperatures in Fig. 12. The supersaturation ratio S is the ratio of the actual condensation pressure p_c to the saturation pressure p_s at the condensation temperature t_c. This temperature is calculated from the initial temperature t_1 by means of the well-known adiabatic relation

$$T_c = T_1(p_c/p_1)^{\frac{(\gamma - 1)}{\gamma}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

The values of S calculated for the condensation pressures shown in Fig. 8 lie near the line calculated for the constant drop size

$r = 1.5 \times 10^{-9}$ ft, by means of the Kelvin-von Helmholtz equation

$$\log_e (p_c/p_s) = \log_e S = \frac{2\sigma}{RT_c dr} \quad \ldots\ldots\ldots\ldots [2]$$

where R = gas constant for steam = 1544/18 = 85.7, ft-lb per deg per lb; T_c = condensation temperature, deg F abs; d = density of the liquid at t_c, lb per cu ft; r = drop radius, ft; and σ = surface tension at t_c lb per ft.

The trend of the points in Fig. 12 would seem to indicate that the size of the drops increases with the temperature, but, for several reasons, it is probable that drop sizes calculated from Equation [2] are not reliable.

An average value of the droplet radius for the points shown in Fig. 12 is 1.5×10^{-9} ft. The molecular radius for water vapor is about 4.5×10^{-10} ft, so the calculated droplet radius is about 3.3 times the molecular radius. It is highly improbable that the Kelvin equation is valid for such extremely small drops.

Size of Droplets. The actual size of the droplets formed in ultimate condensation can only be approximated, because they are so much smaller than the wave length of light that they cannot

Fig. 11 Ratio of Condensation Pressure to Initial Pressure as a Function of the Initial Pressure

be measured directly. Because the light scattered by them is blue and almost completely plane-polarized when observed from a direction normal to the incident light, Rayleigh's law (8, Appendix I) indicates that they are "infinitely small dielectric spheres." This means that they are probably from 10 to 1000 times smaller than the wave length of blue light, which would give them a radius of from 1.5×10^{-7} to 1.5×10^{-9} ft.

Rayleigh's law states that the intensity of light scattered by isotropic spheres which are small compared to the wave length of light varies directly as the sixth power of the radii of the spheres. A number of investigators have shown that the light scattered by molecules can be seen against a very black background. Thus, the light scattered by drops with $r = 1.5 \times 10^{-9}$ ft will be about 1300 times more intense than that scattered by molecules. Such light would be readily visible. Light scattered by drops with $r = 5 \times 10^{-9}$ ft would be a million times as intense as molecularly scattered light.

Kinetic theory yields interesting information about the number of molecules contained in the drops which are formed when con-

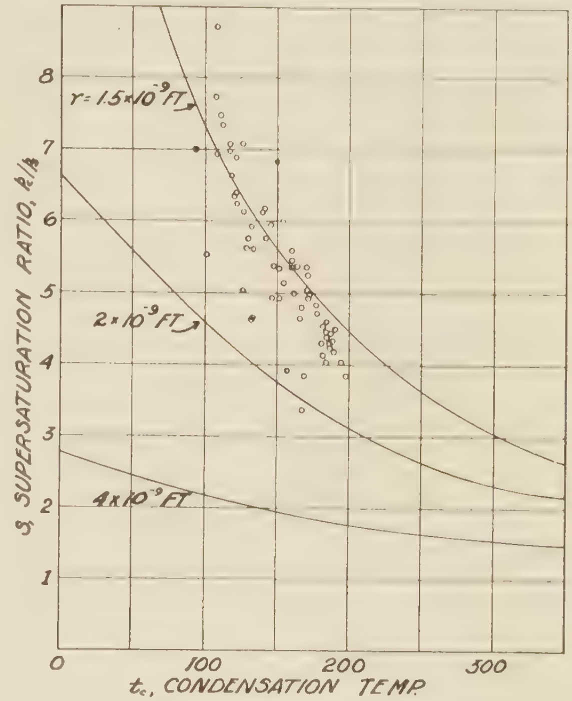


Fig. 12 Supersaturation Ratio Vs Condensation Temperature
(Condensation pressure = p_c; saturation pressure at $t_c = p_s$; $S = p_c/p_s$; and $\log_e S = 2\sigma/RT_c dr$.)

densation occurs. Avogadro's number, the number of molecules per pound molecule of any gas, is 2.75×10^{26}. The molecular weight of water is 18, so the number of molecules per pound is 1.53×10^{25}. The weight per molecule is 6.52×10^{-26} lb. If it is assumed that the molecule is a sphere with radius $r_m = 4.5 \times 10^{-10}$ ft (15, p. 643), the volume of the molecule becomes 3.85×10^{-28} cu ft. The density of the molecule is thus 169 lb per cu ft.

A droplet of water with a radius of 1.5×10^{-9} ft has a volume of 1.42×10^{-26} cu ft. Because of the extremely small size of such a drop, the capillary pressure and the consequent increase in the density should be taken into account. The capillary pressure in pounds per square inch on a droplet of radius r feet, with surface tension σ, is

$$p_{cap} = \frac{2\sigma}{144 \times r} \quad \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

Using a value of $\sigma = 4.8 \times 10^{-3}$ lb per ft, corresponding to 100 F, the capillary pressure in a droplet with $r = 1.5 \times 10^{-9}$ ft is 44,400 lb per sq in. Extrapolating the Keenan and Keyes values for specific volume of compressed liquid (16, p. 75), the density becomes 71 lb per cu ft. The weight of each droplet thus becomes 1.001×10^{-25} lb, and the number of molecules required for a droplet of that weight is 1.57. For several reasons this result is impossible. Obviously, the number of molecules contained in a drop must be integral, and probably a drop, to exist as such, must contain some thousands of molecules. The number 1.57 is inter-

esting, however, in that it might be taken to mean that condensation at the Wilson line consists of the formation of double molecules, as Nernst has suggested (6, p. 1074).

If Keenan's estimate (13) of 5×10^{-9} ft is taken as the droplet radius, the volume of each drop would be 5.24×10^{-24} cu ft, and the weight would be about 3.35×10^{-23} lb. On this basis 514 molecules would be required for such a drop.

It is obvious that such attempts to estimate the drop size from molecular considerations do not lead to any definite results. The concept of surface tension must be abandoned, and replaced by that of molecular attraction. Further optical work, based on the transmitted rather than the scattered light, may yield a more conclusive answer to this question.

The Condensation Process. Speculation as to the physical mechanism by which condensation takes place leads to the difficult conclusion that in some manner the energy released by the moisture at the low temperature t_c is transferred to the remaining vapor, with the result that the temperature of the vapor is raised above that of the supersaturated steam which supplied the heat. This is apparently a violation of the second law of thermodynamics, but it can be shown (6, p. 1036) that the entropy increases during the process, so the law is actually obeyed. The manner in which the energy is transferred is still a mystery, although infrared radiation has been suggested (14, 17, 18). In support of the latter contention it has been pointed out that water vapor has several conveniently located bands in its spectrum by which this radiated energy might be absorbed.

The expansion of steam through a De Laval nozzle apparently occurs in the following manner. Up to and slightly beyond the throat, the steam expands in the same fashion as in the super-

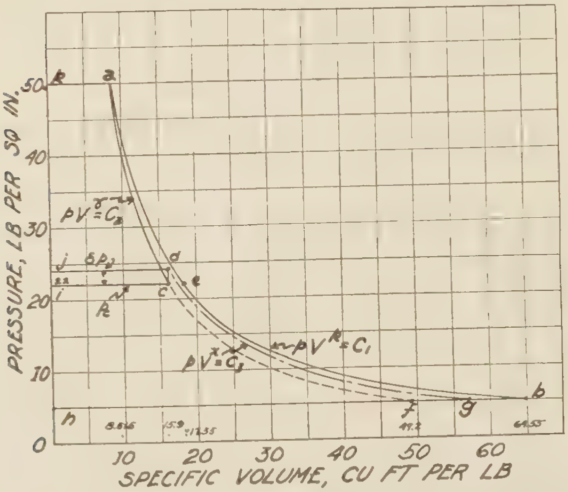


FIG. 13 EXPANSION CURVES FOR WET AND SUPERSATURATED STEAM
(For wet steam $pV^k = C_1$. For supersaturated steam $pV^\gamma = C_2$. For expansion curve d-g, $pV^x = C_3$. Pressure rise $= \delta p$.)

heated region, according to the relation $pV^\gamma = C_1$. The isentropic exponent γ varies with temperature and pressure (16, p. 82), but a value of 1.315 is reasonable for the range in which we are interested. During the expansion, the vapor becomes undercooled with respect to the saturation temperature, and the specific volume is lower than that of wet steam at the same pressure. The expansion follows the line a-c in Fig. 13, while the conventional wet-steam expansion is shown by the line ae. The area between these lines shows the loss which has been caused by supersaturation. A method of evaluating this loss is given in the following section.

When the supersaturation has become sufficiently great, condensation occurs suddenly in the form of a vast number of extremely minute droplets. The latent heat released by the condensed moisture must then be transmitted in some manner to the surrounding vapor, the temperature of which increases. The vapor should expand, but in order to obey the requirements of the continuity equation the velocity would have to increase proportionally. On the contrary, at the condensation point the pressure is observed to rise, which probably means that the process is one of constant volume.

Keenan (13) has shown that this rise of pressure at the condensation point may mean that the drops which actually form are about 5×10^{-9} ft in radius, instead of 1.5×10^{-9} ft as Equation [2] indicates. A similar result can be obtained with the latter drop size, however, if it be assumed that the rise in pressure is just sufficient to maintain constant volume in spite of the increase in temperature which must occur in the vapor.

It has been customary to assume that as soon as condensation occurs, the vapor regains the conventional wet-steam temperature and specific volume (6). The process was considered to be one of constant enthalpy, as shown by the line c-e in Fig 9*a*. Instead, the process is probably one of constant volume, c-d. In addition, the drops which form are so small that the vapor around them must be still undercooled, although to a lesser degree than was the case before condensation. Thus, the temperature at the point d in Fig. 9*b* is lower than the equilibrium temperature at e.

Further expansion probably proceeds from the point d according to the law $pV^x = C_3$ with x having some value between 1.315, for supersaturated steam, and 1.135 for wet steam. For a rough estimate, x may be taken as 1.2.

Analysis of the Effect of Supersaturation. The effect of supersaturation on the flow of steam through nozzles can be treated in the following manner. It has been shown experimentally that, in a rapidly expanding stream, condensation will occur at approximately the same pressure for all initial conditions on the same entropy line. For this reason the following treatment will deal only with expansion from initially saturated conditions. Steam which is initially superheated will behave in the same manner, but it is more difficult to derive general expressions for the losses.

For expansions down to but not below p_c, the following analysis can be made. From the general energy equation for steady flow in an isentropic expansion comes the following basic relation

$$\frac{v_1^2}{2g\,778} + h_1 = \frac{v_2^2}{2g\,778} + h_2 \qquad [4]$$

or

$$v_2^2 - v_1^2 = 50{,}000 \times \Delta h_i$$

where Δh_i is the isentropic change in enthalpy between conditions 1 and 2. Combining the continuity equation

$$w = \text{lb per sec} = \frac{A_1 v_1}{V_1} = \frac{A_2 v_2}{V_2} \qquad [5]$$

with the gas relation for isentropic expansion

$$p_1 V_1^\gamma = p_2 V_2^\gamma \qquad [6]$$

we obtain the relation

$$v_2^2(1 - m^2\beta^{2/\gamma}) = 223.7\sqrt{(\Delta h_i)} \qquad [7]$$

where m is the area ratio A_2/A_1, and β is the pressure ratio p_2/p_1. Since the expansion is assumed to be isentropic

$$\Delta h_i = \int_1^2 V dP = \frac{144\,\gamma}{778\,\gamma - 1}\, p_1 V_1 \left(1 - \beta^{\frac{\gamma - 1}{\gamma}}\right) \qquad [8]$$

Thus the velocity after the expansion becomes

$$v_2 = \sqrt{\left[2g\,\frac{\gamma}{\gamma-1}\,144\,p_1V_1\left(\frac{1-\beta^{\frac{\gamma-1}{\gamma}}}{1-m^2\beta^{2/\gamma}}\right)\right]} \quad\ldots\ldots\ [9]$$

By combining Equations [5] and [9], we obtain the general equation for the flow of a compressible fluid in lb per sec through a nozzle with throat area A_2 sq ft, or

$$w = A_2\sqrt{\left[2g\,\frac{\gamma}{\gamma-1}\,144\,\frac{p_1}{V_1}\left(\frac{\beta^{2/\gamma}-\beta^{\frac{\gamma+1}{\gamma}}}{1-m^2\beta^{2/\gamma}}\right)\right]} \quad\ldots\ [10]$$

Usually we may neglect the term $1/\sqrt{(1-m^2\beta^{2/\gamma})}$, which corrects for the velocity of approach.

For initial pressures up to about 300 lb per sq in. abs, the condensation pressure is always below the critical-pressure ratio, $\beta = 0.55$. Thus, supersaturation will always prevail at least to the throat of nozzles with these initial pressures and the flow

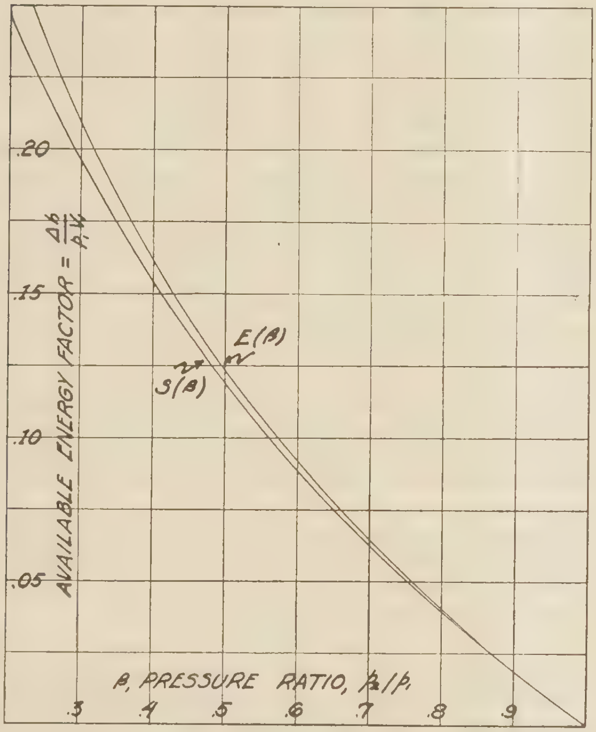


Fig. 14 Available Energy Factors as Functions of the Pressure Ratio p_2/p_1

$\Delta h_e = E(\beta)p_1V_1$ with $k = 1.135$. $\Delta h_s = S(\beta)p_1V_1$ with $\gamma = 1.315$.

$$E(\beta) = \frac{144}{778}\,\frac{k}{k-1}\left[1-\beta^{\frac{k-1}{k}}\right]$$

$$S(\beta) = \frac{144}{778}\,\frac{\gamma}{\gamma-1}\left[1-\beta^{\frac{\gamma-1}{\gamma}}\right]$$

should be calculated by using the superheat value of γ in Equation [10]. For example, assume that saturated steam at 50 lb per sq in. abs is flowing through a nozzle of 1 sq in. throat area against a back pressure of 30 lb per sq in. abs. The flow will be about 2760 lb per hr, whereas the calculated flow, using k for wet steam instead of γ as the exponent in Equation [10], would be about 2590 lb per hr. Thus, the flow coefficient would be about 1.068. Such anomalous flow coefficients have frequently been observed with wet or slightly superheated steam, and they were the principal reason for much of the work which has been done on the subject of supersaturation.

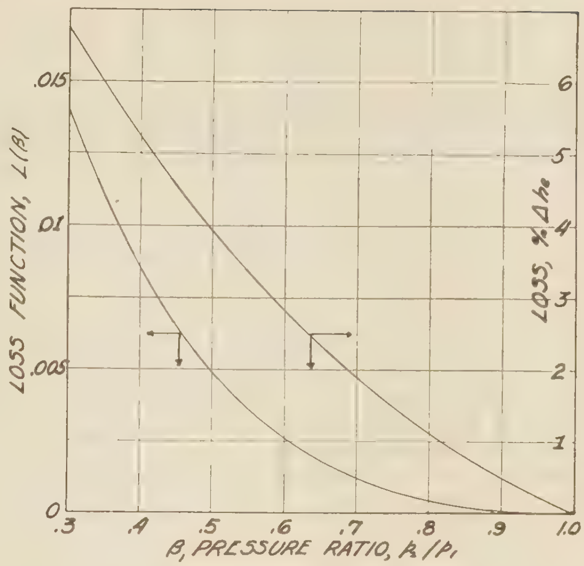


Fig. 15 Values of Loss Function $L(\beta)$ and Percentage Loss Δh_e
(Per cent loss $= (\delta h/\Delta h_e)100$, where $\delta h = p_1V\,L(\beta)$.)

In general, the purpose of a nozzle is to convert into kinetic form the energy made available by the expansion of a gas. The available energy is the isentropic enthalpy change from the initial to the final conditions, for which a general expression appears in Equation [8]. It can readily be seen that the energy available in an expansion from an initial condition p_1, V_1 is a function of the pressure ratio β and the isentropic exponent. Thus, it is possible to write

$$\Delta h_i = p_1V_1 f(\beta) \quad\ldots\ldots\ldots\ldots\ldots\ [11]$$

where

$$f(\beta) = \frac{144}{778}\,\frac{\gamma}{\gamma-1}\left(1-\beta^{\frac{\gamma-1}{\gamma}}\right)$$

By using the proper value of the exponent γ in Equation [8], we may obtain the available energy for either a supersaturated expansion or a conventional wet-steam expansion. Thus, the energy available in an expansion from p_1, V_1 in which the steam is assumed to be in equilibrium with large drops of water can be calculated by replacing γ with the wet-steam exponent k. The value of k varies with the entropy of the expansion, but an average value is 1.135. Denoting by Δh_e the heat available in such an expansion, we have

$$\Delta h_e = p_1V_1\,E(\beta) \quad\ldots\ldots\ldots\ldots\ldots\ldots\ [12]$$

and

$$E(\beta) = 1.555\,(1-\beta^{0.119}) \quad\ldots\ldots\ldots\ldots\ [13]$$

The energy available in a completely supersaturated expansion from the same initial conditions p_1, V_1, can be expressed in the same manner, or

$$\Delta h_s = p_1V_1\,S(\beta) \quad\ldots\ldots\ldots\ldots\ldots\ldots\ [14]$$

Using the value 1.315 for γ in Equation [11], we have

$$S(\beta) = 0.772\,(1-\beta^{0.2395}) \quad\ldots\ldots\ldots\ldots\ [15]$$

These two functions are plotted against β in Fig. 14.

The loss due to supersaturation is represented by the difference between Δh_e and Δh_s. Graphically it is shown by the area between the two expansion curves on the pV-diagram in Fig. 13. Denoting the loss in Btu per pound by δh, we have,

$$\delta h = \Delta h_e - \Delta h_s = p_1V_1\{E(\beta)-S(\beta)\} \quad\ldots\ldots\ldots\ [16]$$

Combining Equations [13] and [15], we have

$$\delta h/p_1V_1 = L = L(\beta) = 0.783 - 1.555\ \beta^{0.119} - 0.772\ \beta^{0.2395} \quad \text{..[17]}$$

Values of the loss function $L\ (\beta)$ can be taken from Fig. 15.

For design work, the loss expressed as percentage of Δh_s is of importance, since Δh_s can be read directly from the Mollier diagram. The loss δh expressed in per cent is

$$\text{per cent } \delta h = \frac{\delta h}{\Delta h_s} \times 100 = \left(1 - \left[\frac{\Delta h_s}{\Delta h_s}\right]\right) \times 100 = \left(1 - \left[\frac{E(\beta)}{S(\beta)}\right]\right) \times 100 \quad \text{..........[18]}$$

Per cent δh is plotted against β in Fig. 15.

Since the product p_1V_1 varies with the initial conditions, the actual loss δh, in Btu per pound, also varies; Fig. 16 shows the losses for initial conditions of 10, 50, and 100 lb per sq in. abs, saturated. Since the loss functions discussed previously are not valid beyond the condensation point, each of the lines on Fig. 16 stops at its particular condensation pressure. It will be noticed that the supersaturation loss is decreased as the initial pressure is raised. This is to be expected, for if the pressure is raised to the critical point, there will be no supersaturation and hence no loss.

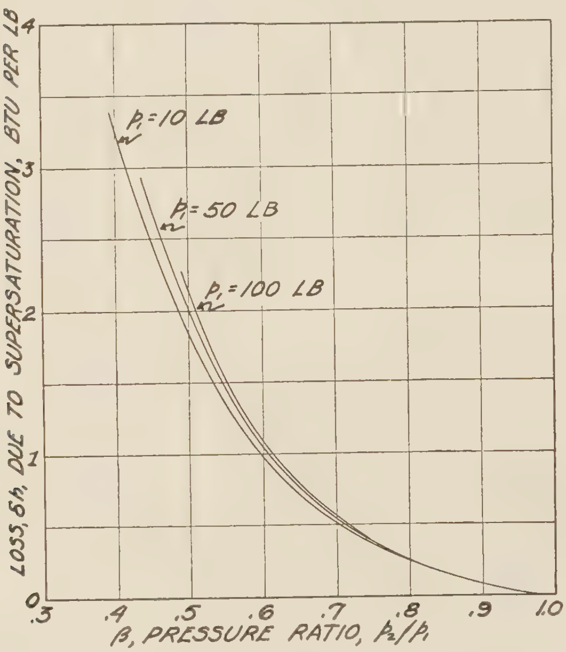


Fig. 16 Loss Due to Complete Supersaturation; Values Not Valid Beyond Condensation Pressure

By referring to the pV diagram in Fig. 13, it can be seen that when an expansion proceeds beyond the condensation pressure p_c there is a sharp recompression to d, probably at constant volume. This recompression causes a momentary decrease in the kinetic energy, but this decrease is regained as soon as the expansion again passes p_c. The total loss due to supersaturation for expansions beyond the condensation pressure is made up of the loss δh discussed previously, plus a secondary loss caused by the partially supersaturated expansion from d. The droplets which form at c are so small that undercooling must still exist as the expansion proceeds. Evaluation of this secondary loss is not yet possible because the magnitude of the pressure rise from p_c to p_d must be studied in more detail. Likewise, the exponent x for the expansion beyond d is not known. An additional factor which must be considered is the acceleration of the water droplets by the steam.

An estimate of the total losses of energy which occur in the expansion of saturated steam can be made from the results of several tests reported by Stodola (6, p. 1054). In the first case, steam expanding from 116 lb per sq in. abs and 7 F superheat, to a back pressure of 15.4 lb per sq in. abs, gave a reaction of 23.92 lb with a flow of 0.298 lb per sec. The velocity coefficient was 0.95 and the nozzle efficiency was 90 per cent. In the second case, the initial conditions were 158.7 lb per sq in. abs and 15 F superheat; the back pressure was 8.13 lb per sq in. abs; and the reaction was 38.80 lb with a flow of 0.399 lb per sec. The velocity coefficient for this case was 0.94 and the nozzle efficiency was 88.5 per cent.

Summary of Results

As a primary result of this work, it may be said that the Wilson line for continuously expanding steam in De Laval nozzles is located at about the 4.5 per cent moisture line on the Mollier diagram. The droplets which form there are small compared to the wave length of blue light and they do not grow in the nozzle unless the angle of divergence is less than 2 deg.

Initially saturated steam can in several ways be made to condense at about the 2 per cent moisture condition, which thus becomes the upper limit of the Wilson zone. This type of condensation can be brought about by making the angle of divergence less than 2 deg or by raising the back pressure to within a few pounds of the initial pressure. Under these conditions, the drops grow rapidly and usually achieve a size of the order of magnitude of red light waves as they leave the nozzle.

Steam which is initially superheated can be made to produce preliminary condensation only if the throat of the nozzle is very long.

It is estimated that the order of magnitude of the radius of the droplets formed in ultimate condensation is about 1.5×10^{-9} ft. This value was obtained by applying the Kelvin law, the accuracy of which is very doubtful, but the optical evidence gives support to it.

The losses caused by supersaturation can be evaluated accurately for expansions which do not reach the condensation point. For expansions which go beyond this point the losses can be approximated.

Acknowledgments

Although the number of those who have rendered assistance in various stages of the work is so great that individual mention cannot be made, the authors wish especially to acknowledge their indebtedness to Prof. J. W. Gavett of the University of Rochester and to the staff of the department of mechanical engineering of Stevens Institute. Financial assistance from The American Society of Mechanical Engineers is gratefully acknowledged, and the authors wish to express their gratitude to Geo. A. Orrok and C. B. Le Page. The actual construction of the apparatus was done by Carl Oelkrug of Stevens Institute, and his precise workmanship was invaluable.

BIBLIOGRAPHY

1 "Condensation of Water Vapour in the Presence of Dust-Free Air," by C. T. R. Wilson, Philosophical Transactions of the Royal Society of London, series A, vol. 189, 1897, pp. 265–307.

2 "Conduction of Electricity Through Gases," by J. J. Thomson, Cambridge University Press, London, vol. 1, edition 3, 1928.

3 "A New Theory of the Steam Turbine," by H. M. Martin, *Engineering*, vol. 106, 1918, pp. 53–55, 107–108, 151–162, 189–191, and 245–246.

4 "The Supersaturation Limit," by H. M. Martin, *Engineering*, vol. 115, 1923, p. 607.

5 "Steam and Gas Turbines," by A. Stodola, McGraw-Hill Book Company, New York, N. Y., vol. 1, 1927, p. 117.

6 "Steam and Gas Turbines," by A. Stodola, McGraw-Hill Book Company, New York, N. Y., vol. 2, 1927, p. 1034.

7 "Supersaturation and the Flow of Wet Steam," by G. A. Goodenough, *Power*, vol. 66, September 27, 1927, pp. 466–469.

8 "Supersaturated Steam," by John I. Yellott, Trans. A.S.M.E., vol. 56, 1934, paper FSP-56-7, pp. 411–430.

9 "Undercooling in Steam Nozzles," by J. T. Rettaliata, Trans. A.S.M.E., vol. 58, 1936, paper FSP-58-6, pp. 599–605.

10 "Abriss der Strömungslehre," by L. Prandl, Friedr. Vieweg and Son, Aktiengesellschaft, Braunschweig, 1931, p. 203.

11 "Uber die Ausströmungserscheinungen permanter Gase," by R. Emden, *Annalen der Physik und Chemie*, vol. 69, 1899, pp. 264–289 and 426–453.

12 "Optische Untersuchung der Luftstrahlen," by E. Mach and P. Salcher, Sitzungsberichte die Akademie der Wissenschaften in Wein, Ab. 2A, vol. 98, 1889, p. 1303.

13 Discussion by J. H. Keenan of "Supersaturated Steam," by John I. Yellott, Trans. A.S.M.E., vol. 56, 1934, paper FSP-56-7, p. 427.

14 "Supersaturation in Steam and Its Influence Upon Some Problems of Steam Engineering," by C. F. Powell, *Engineering*, vol. 127, 1929, pp. 711–713, and 779–780.

15 "Kinetic Theory of Gases," by L. B. Loeb, McGraw-Hill Book Company, New York, N. Y., second edition 1934.

16 "Thermodynamic Properties of Steam," by J. H. Keenan and F. G. Keyes, John Wiley & Sons, Inc., New York, N. Y., 1936.

17 "Super-Saturated Expansion," *Engineering*, vol. 123, 1927. pp. 535–537.

18 "Supersaturation," *Engineering*, vol. 127, June 1, 1929, pp. 791–792.

Production and Quality Control of Sheets for Automobile-Body Fabrication

By T. F. OLT,[1] MIDDLETOWN, OHIO

Comparisons of the older and newer methods of rolling wide mild-steel drawing sheets are presented in this paper. The aspects of quality control in the modern sheet mill are dealt with, and quantitative data are given covering the effects of variations in the cold-reduction, normalizing, box-annealing, and temper-rolling operations. The data presented are typical rather than exhaustive.

PROGRESS in the sheet-rolling industry has been rather extensive within the last decade, and one of the most interesting phases of this development has been the growing demand for wider and thinner high-finish drawing sheets than were obtainable heretofore. Considering the number of years they have been available, the production of wide high-finish drawing sheets might be said to be in its early stages. Even so recently as eight years ago, a 19-gage sheet measuring 52 × 58 in. was considered to be quite large, and the losses connected with the production of sheets of this size on the prevailing sheet-bar practice were quite high. In those days high-finish sheets were still being rolled from the conventional 8-in. sheet bar, using the practices that had been developed during the past century, plus, of course, the most recent developments such as pickled breakdowns, charcoal dips, and loose rolling. In 1921, The American Rolling Mill Company purchased the Ashland Iron and Mining Company property, which lacked sheet-finishing facilities, and proceeded to install the first commercially successful so-called "continuous-sheet mill." (1)[2] The problems connected with the development of this mill were many and varied, one of the principal difficulties being to secure rolls which would stand up under continuous operation. However, this problem was overcome and the mill was made to produce sheets up to 48 in. wide in 20 gage and heavier with very good surface characteristics and drawing properties.

Previous to 1921, a very good quality of strip was available in widths up to 20 in. which was being produced on continuous cold strip mills. So far as surface and drawing quality were concerned, this product was superior, by a considerable margin, to sheet products available. However, in November, 1926, The Columbia Steel Company, which a few months later became the Butler Division of The American Rolling Mill Company, commenced the rolling of strip sheets (2) in coils in widths up to 36 in., using a combination of hot and cold rolling similar to the practice used in the narrower strip mills, the main difference being in the equipment and mills which handled the strip. The installation at Butler was quickly followed by others at Weirton to hot roll strip up to 48 in. wide, at Trumbull to hot roll strip up to 36 in. wide, at The American Sheet and Tin Plate Company, Gary, Ind., to hot roll strip up to 36 in. wide, and at the Middletown Division of Armco in 1928 to hot roll strip up to 52 in. wide. Fig. 1 is a view of the finishing stands of the Middletown hot-strip mill.

With the construction of the wide hot-strip mill at Middle-

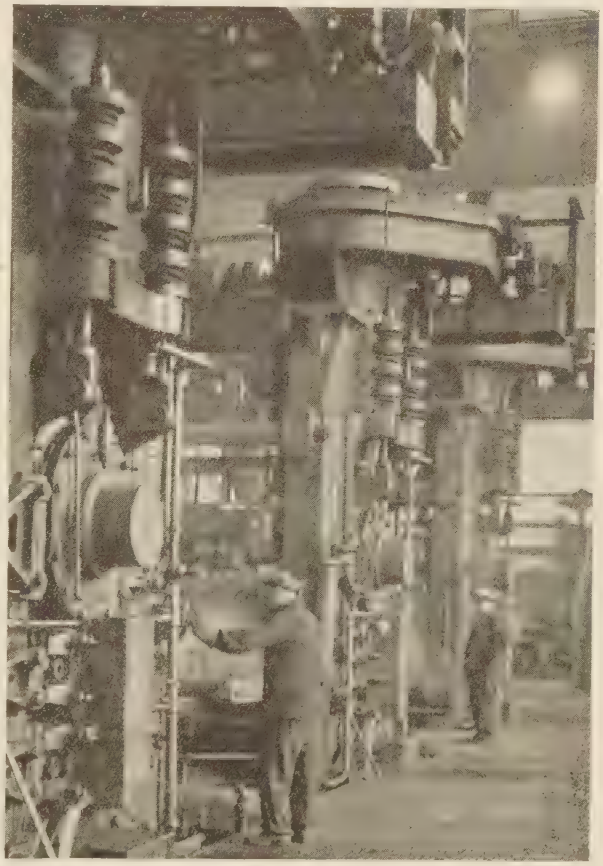


Fig. 1 Finishing Stands in the Hot-Strip Mill of the Armco Middletown Division

[1] Research Laboratories, The American Rolling Mill Company, Middletown, Ohio. Mr. Olt was graduated from the University of Cincinnati in 1928 with the degree of chemical engineer and since graduation has been associated with The American Rolling Mill Company. Previous to 1934 he was employed in the operating division in various metallurgical capacities. Since 1934 he has been in the research laboratories in charge of the research and development of high-finish drawing sheets and stainless-steel products.

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Iron and Steel Division for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held at Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until June 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

town, the sheet mill was rebuilt to use the product of the hot-strip mill as breakdowns for the hot finishing of sheets, using continuous-pack heating furnaces and three-high hot mills (similar to those in successful use at Ashland on narrower widths) for the production of sheets 50 in. and wider. By 1932 the production of thin-gage wide and long sheets had progressed to such a point that sheets 0.037 in. thick and as large as 66 × 120 in. made on hot mills were available to the automotive industry in

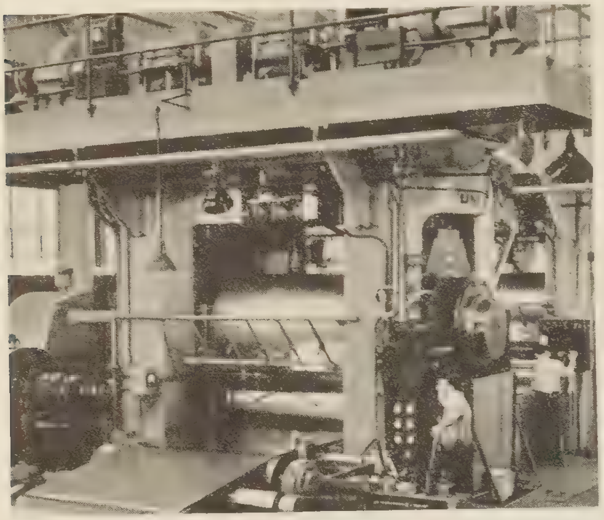


Fig. 2 The Cold-Strip Mill of the Armco Middletown Division

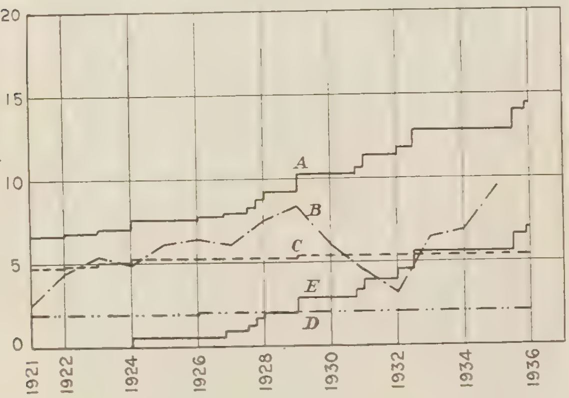


Fig. 3 Capacity and Production of Sheet and Strip Mills in the United States

(*A*, Capacity of plate, sheet, and strip mills. *B*, Total sheet and strip production. *C*, Capacity of sheet mills. *D*, Capacity of tin-sheet mills. *E*, Capacity of strip mills.)

quantities large enough for the production of certain items requiring wide high-finish sheets.

During this period, wider and more powerful hot-strip mills were in the process of being built first to roll sheets 60 in. wide, then 72 in. wide, and then 90 in. wide. At present there is a new construction in Cleveland which is reported (3) to have a width limit of 98 in. In 1936, the hot-strip mill at the Middletown Division of Armco was widened (4) to 80 in. to provide wide coils for the cold-strip mill which has recently been constructed there. Fig. 2 is a view showing the Middletown coldstrip mill. Fig. 3 is a diagrammatic representation (5) of the volume and capacity of sheet production in the United States which indicates that the growth of sheet capacity since 1924 has been almost entirely in the continuous-strip process of making sheets. In this same period, cold-rolling mills have been improved continuously with better reels, rolls, bearings, electrical gear, and controls which enable cold reduction to be performed on coils at high speeds under very definitely controlled conditions of screw pressure, thickness, and tension between tandem stands.

Comparison of the Sheet and Strip Practice in the Manufacture of Wide Sheets for Drawing Purposes

There are numerous methods by which a wide cold-rolled sheet of drawing quality may be produced. For purposes of comparison, consider a sheet 0.040 in. thick, 63 in. wide, and 103 in. long, which in the present day is neither unusually wide, long, nor thin. In the first place, the quality and analysis of the steel used is of utmost importance. The quality must always be good and the analysis will depend to a great degree on the methods selected for manufacture of the sheet and the drawing or stamping hazards which the sheet must undergo.[3] Steel used for difficult stampings is usually of the rimming type, with an analysis in the following range: Carbon from 0.04 to 0.10 per cent; manganese from 0.20 to 0.45 per cent; phosphorus below 0.04 per cent; sulphur below 0.05 per cent; and other elements as low as possible.

In the casting of an ingot within the composition given, there is a segregation of some of the elements involved which must be taken into consideration in selecting the method of rolling and processing for the material being produced. Fig. 4 gives an indication of the amount of segregation that is sometimes obtained in casting a rimming steel ingot. It will be seen that there is a segregation of carbon, copper, and sulphur which

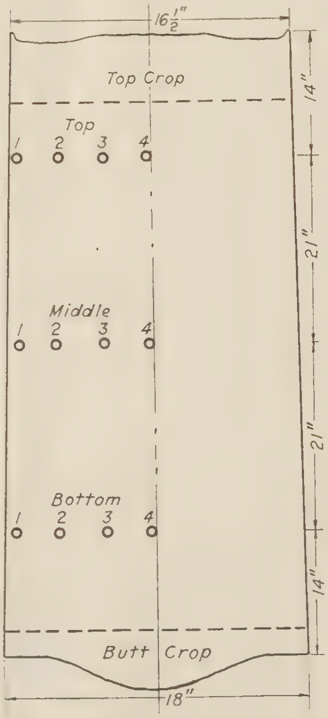


Fig. 4 Segregation in an 18 × 39 70-In. Ingot of Rimming Steel. Section Through the Middle of the 39-In. Width

ANALYSIS OF LADLE SAMPLE AND AT DIFFERENT POINTS IN THE INGOT

		Ingot — Top				Ingot — Middle				Ingot — Bottom			
	Ladle	1	2	3	4	1	2	3	4	1	2	3	4
C........	0.086	0.070	0.036	0.094	0.094	0.071	0.040	0.078	0.079	0.058	0.041	0.062	0.060
Mn......	0.410	0.420	0.370	0.440	0.440	0.410	0.380	0.420	0.420	0.400	0.380	0.380	0.380
S........	0.018	0.023	0.016	0.029	0.031	0.020	0.015	0.026	0.026	0.016	0.014	0.022	0.018
Cu......	0.081	0.083	0.078	0.099	0.099	0.082	0.081	0.090	0.091	0.084	0.084	0.091	0.090

[3] The drawing and stamping hazards will vary somewhat between different fabricating plants on the same type of stamping, and for this reason it is necessary to maintain an extremely close contact between the mill and fabricator in order to maintain a steady flow of material suitable for the particular job concerned.

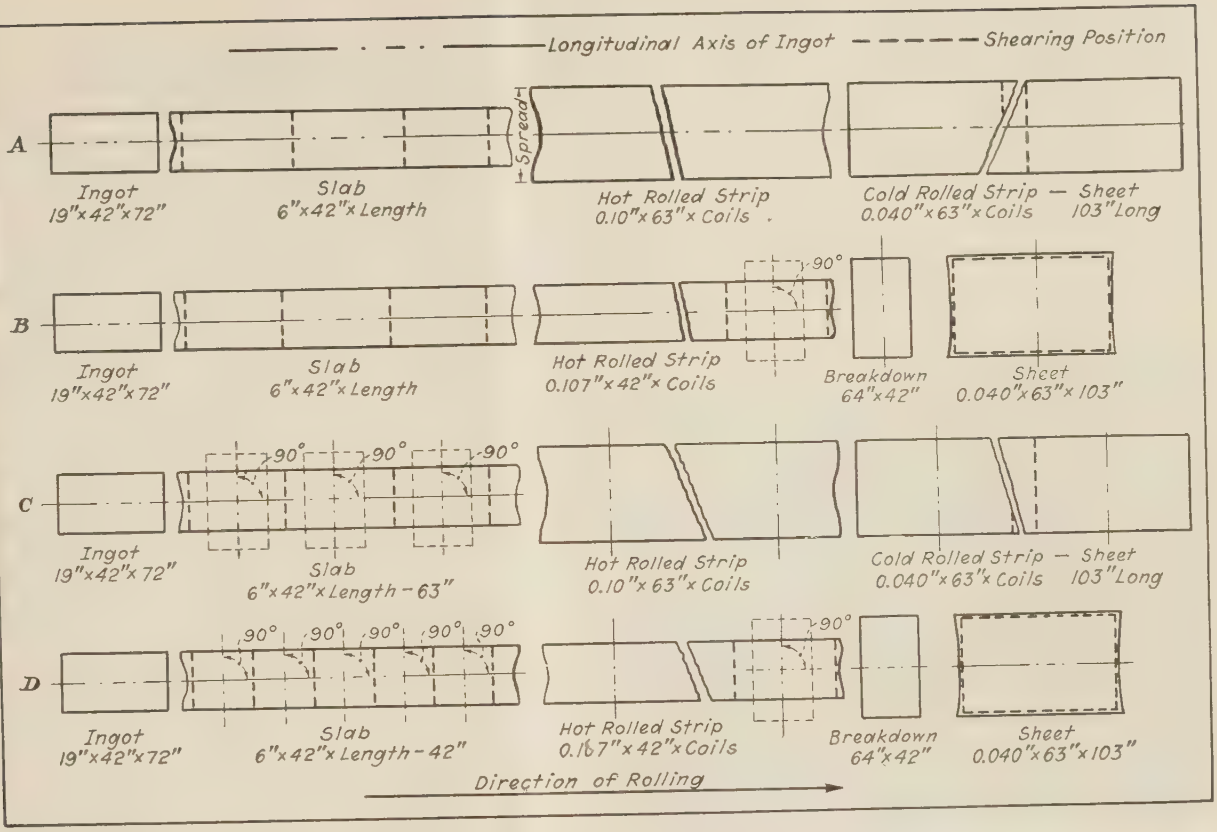


FIG. 5 VARIOUS METHODS OF ROLLING WIDE SHEETS

(*A*, Ingot rolled essentially straight throughout. *B*, Ingot rolled straight to hot strip, hot strip turned and hot rolled to finished gage. *C*, Ingot rolled to slab, and slab then turned and rolled to finished gage. *D*, Ingot rolled to slab, and slab then turned and hot rolled to hot-strip breakdown gage, after which the hot-strip breakdown is again turned and then hot rolled to finished gage.)

are all potent hardeners. In making ingots for deep drawing sheets, special efforts are made to keep the segregation of elements to a minimum.

The four methods by which the sheet we are considering can be rolled to finished gage are shown schematically in Fig. 5.

The first method is used to a very great extent in the narrow-strip mills and many of the wide-strip mills to make sheets up to a width approaching that of the ingot. To make sheets wider than the ingot, this method can be modified by spreading the slab laterally in the first stand of the strip mill to a width suitable to produce the desired width of strip, which very seldom requires a reduction greater than 50 per cent of the original slab thickness. If we start with an ingot 19 in. thick, 42 in. wide, and 72 in. high, and roll to strip having a thickness 0.10 in. and a width of 63 in., the ratio of the strip to ingot will represent an elongation of 126.5 times parallel and 1.50 times transverse to the long dimension of the original ingot. When rolled to the finished gage of 0.040 in., the elongation will be 316 times and the lateral spread 1.50 times from the original ingot. Had the sheet been rolled to a width of 42 in., there would have been no lateral spread except the small amount that always takes place when metal is rolled, and the elongation in this case, considering a final gage of 0.040 in., would have been 475 times.

The second method mentioned is not often used in the manufacture of wide sheets except for some particular reason; however, the practice of making sheets from sheet bar is similar to this process, the difference being in the division of the reduction that is parallel and that which is transverse to the axis of the ingot. In the case of sheet hot rolled from strip breakdowns, the division of elongation is 183 times parallel and 2.59 times transverse to the ingot axis. In the case of this sheet hot rolled from 8-in. sheet bar, which would probably be made from a 19 × 22-in. ingot, the division of elongation is 91.5 times parallel and 5.2 times transverse to the axis of the ingot. The latter is a net figure, since the final rolling from an 8-in. sheet bar is an elongation of 14.2 times while the sheet bar was contracted 2.75 times.

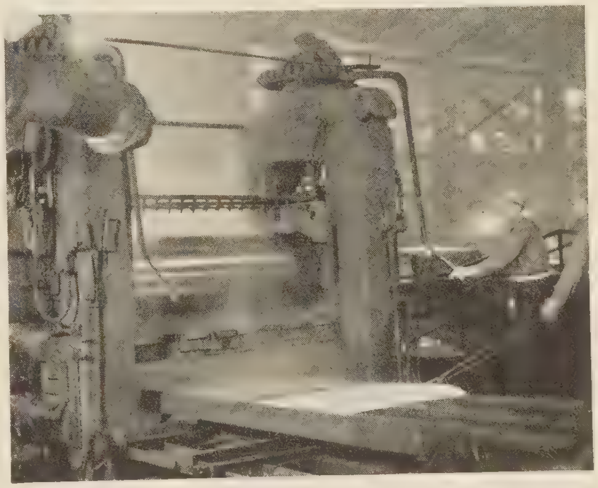


FIG. 6 THREE-HIGH HOT FINISHING MILL

The third method is the one ordinarily used in the Armco Middletown Division in the manufacture of wide sheets by the cold-reduction process. In this case the ingot is slabbed, turned, and hot rolled to strip approximately 0.10 in. thick. The slab length, and hence its thickness, depends upon the desired width of the hot-rolled strip. For instance, if the strip mill is to roll coils 63 in. wide, the length of the slab must be such that they can get three 63-in. cuts and still have enough metal to get the necessary croppage. If they plan to roll a strip 40 in. wide the slab is rolled to a length suitable to get four cuts plus croppage. After rolling on the hot-strip mill, the strip is then pickled and cold rolled to the desired thickness of 0.040 in. The elongation in this case is 3.16 times parallel and 150 times transverse to the ingot axis.

Fig. 7 Two-High Hot Mill

The fourth method mentioned is used at Middletown when hot-strip breakdowns are hot rolled to sheets using the three-high hot mill. Fig. 6 shows a typical three-high mill. The ingot is slabbed to 6 in., reheated, turned and rolled to breakdown thickness, sheared to length equal to the width of the desired sheet plus side scrap, then turned again and rolled to gage. The elongation of the sheet in this case is 8.2 times parallel and 58.0 times transverse to the axis of the ingot.

All of these methods of rolling have certain advantages and disadvantages. The first two methods allow the production of longer and heavier units of semifinished product such as hot-rolled coils with a somewhat greater yield from the ingot. In cross-rolling slabs, the weight of the coil is limited by the slab thickness the first stand in the bar mill will take, and also the maximum reductions that can be taken in producing the desired thickness in the hot-rolled coil with the mills available, together with the maximum ingot width that can be handled in the slabbing mill. In addition, it is necessary to roll the slabs very closely to the desired slab length in order to secure the proper yield from the ingots, since the losses mount rapidly if the slabs are rolled with too much croppage on either end. On the other hand, if the slab be too short, an entire cut is lost which may amount to as much as, or more than, one third of the ingot. The greatest advantage in cross-rolling is that the resultant sheets are more uniform within the single sheets in so far as segregation effects are concerned. Sheets produced by this method do not have a soft edge and hard center from the more segregated portion of the ingots, which is the case when the material is rolled straight essentially throughout the whole reduction. The magnitude of this difference in properties is shown in Table 1.

This is a very important consideration in drawing sheets for some requirements, since a variation in physical properties between the edges and the center of sheets will sometimes cause a lack of uniformity in the manner in which the metal flows in the drawing dies. When the complete product of any one ingot is concerned, however, the whole range in physical properties is secured by either practice; in fact, in cross-rolling slabs, the major portion of scrap which is subsequently lost (coil crops) represents some of the least segregated metal of the original ingot.

As pointed out, a sheet 0.040 in. thick, 63 in. wide, and 103 in. long can be made either by hot reduction or cold reduction from hot-rolled strip approximately 0.10 in. thick. The most modern method is to reduce to the finished sheet gage cold rather than hot. The most important reasons for the selection of the cold-reduction process are economy, improved quality, decreased losses, and flexibility.

In the older hot-rolling process for manufacturing wide sheets, the customary procedure is as follows: (*a*) Pickle hot-rolled strip in cut lengths; (*b*) heat and breakdown to 80 per cent finished sheet length; (*c*) pickle breakdown; (*d*) reheat breakdowns and roll to length; (*e*) mill shear; (*f*) cold roll to flatten and even thickness; (*g*) normalize; (*h*) pickle; (*i*) bright anneal; (*j*) temper pass and roller level; and (*k*) inspect.

The oldest method of hot rolling sheets from sheet bar is similar to the foregoing practice except that more heatings and breakdowns are required in the sheet mill. Fig. 7 is typical of the old style two-high hot mill for sheet bars.

As a comparison, the customary sequence of operations in the manufacture of wide sheets by the most modern cold-reduction method consists of: (*a*) Pickle hot-rolled strip in coils; (*b*) cold roll to gage; (*c*) shear to length; (*d*) bright anneal; (*e*) temper pass and roller level; and (*f*) inspect.

A comparison of these two general practices will indicate that the old hot-rolling method requires five more separate operations than the modern cold-reduction method, and being performed in unit sizes entails the production of a great deal more scrap than is produced by the cold method. In addition, there are always a great many more rolling rejections such as pinchers, jumpers, and floppers produced in hot rolling than in the most modern methods of cold reduction where the rolling is performed with very rigid mills equipped with tension coilers and also tension

TABLE 1 DIFFERENCE IN PHYSICAL PROPERTIES FROM EDGE TO CENTER OF SHEET IN STRAIGHT-ROLLED SHEETS TEMPERED 0.7 PER CENT

	Cold-reduced and annealed		Cold-reduced, normalized and box-annealed	
Top of ingot:	Edge	Center	Edge	Center
Yield strength, lb per sq in.	23730	32660	27000	33000
Tensile strength, lb per sq in.	40800	46860	44600	50600
Elongation, per cent in 2 in.	43.3	38	41.3	37.7
Rockwell hardness, B scale	37	48	41	50
Bottom of ingot:				
Yield strength, lb per sq in.	27250	30430	27500	29800
Tensile strength, lb per sq in.	43430	44900	46100	47600
Elongation, per cent in 2 in.	40.3	38	40.7	39.3
Rockwell hardness, B scale	37	47	42	48

TABLE 2 SELLING PRICE PER TON OF HIGH-FINISH 63 × 103-IN. OILED DRAWING SHEETS 0.04 IN. THICK, F.O.B. PITTSBURGH, PA.

	July 1, 1928	July 1, 1932	July 1, 1936
Base price[a]	$80	$55	$61
Extras[b]	42	14	8
Total	132	69	69

[a] Price of 20-gage sheets.
[b] Extras include width, quality, and oiling.

between the tandem stands. Another outstanding advantage of the cold-reduction process is in the improvement of the sheet surface both from the standpoint of freedom from defects as well uniformity of appearance.

The differences between the old and new methods of manufacturing wide sheets have been indicated in the foregoing tabulations of the sequence of operations and will be considered at greater length and in more detail in the next paragraphs. It is largely due to the rolling methods, however, that it has been possible to decrease the costs and increase the yield of prime high-finish sheets so that the sheet manufacturers have been able to reduce the cost to the consumer as is shown in Table 2.

The net price in 1936 is the same as the price in 1932 despite the fact that labor and raw-materials costs have been increased materially. In this discussion, it has been presumed that the cost of production and selling price are interrelated, which is usually the case in a highly competitive market such as the sheet market.

By decreasing the selling price of wide drawing sheets, the fabricator has been enabled to make single stampings, formerly made in multiple parts and assembled, at decreased costs which has resulted in greater sales, and hence, greater demand on the sheet producer. This expanded demand for sheets has further reduced costs of manufacture with resultant savings to the sheet consumer.

It will be apparent from the foregoing, that for two hundred years the art of rolling sheets had not changed in method and but little in practice. However, after the first successful continuous mill was operated by The American Rolling Mill Company at Ashland, Kentucky, in 1924, the flat-rolled-steel industry spent in the neighborhood of $300,000,000 for new rolling equipment which provided material in sizes and tonnages not previously considered possible. At the same time it has made an improved quality of material available for the automobile industry at a reduction in cost of approximately 50 per cent.

Quality Control in the Modern Sheet Mill

There are numerous factors which must be considered in order to produce a satisfactory sheet for some particularly difficult drawing requirement. As stated previously, by far the most important consideration is to have a satisfactory base material from which to start.

There has been a constant drive in the open-hearth to make lower-carbon rimming-steel ingots to almost a spot specification, taking particular care to see that there is a minimum of alloy contamination. This job has been made constantly more difficult due to the scarcity of the most desirable raw materials. The available pig iron or hot metal contains more copper, if the blast furnace is being scrapped to increase the output, and the scrap commercially available is constantly being contaminated with alloying elements such as copper, nickel, and chromium, being generated in this age of alloy steels. While alloy scrap is usually sold separately from the regular run of No. 1 and No. 2 scrap because of its higher value, it is mixing in with the open-hearth scrap to an ever increasing extent. In order that the proper analysis be obtained in the ingot, it is often necessary that scrap be selected and the charge melted in such a manner that the sulphur content be low. Metallurgical observers stationed in the open hearth are constantly on the job to make certain that all vital operations are carried out according to prearranged plans, that the heat has the proper temperature when tapped and poured, and that the steel has the proper rimming action in the molds.

After the ingots are stripped (and care is taken to see that they are not stripped too soon), the ingots are charged into the soaking pits and carefully heated for rolling. Temperatures are regularly checked in the pits, at the slabbing mill, at the slab shears, and between certain stands in the bar and hot-strip mill by recording radiation pyrometers in order to maintain uniformity of rolling conditions and grain structure. Fig. 8 shows such an instrument installed. Cooling water is used copiously to insure that the strip is not reeled into coils at temperatures sufficiently high to cause critical grain growth. The strip mill has numerous banks of high-pressure hydraulic sprays which are used to descale the strip. It is vitally important that the surface of the hot-rolled strip be free from scale matte or rolled-in scale if the finished sheet is to be satisfactory for fabrication into many products requiring a smooth surface. A careful watch must be maintained on the surface of the rolls in all of the stands in the strip mill, watching particularly for spawls, fire cracks, and pickup

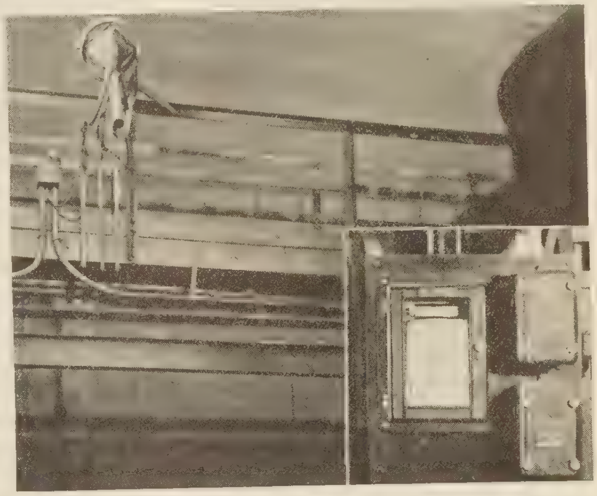


Fig. 8 Radiation Pyrometer and Continuous Recorder at the Finishing Stand in the Hot-Strip Mill

the results of which often do not show up until the sheets are being drawn in the fabricator's plant where the roll defects show up as slivers and fins. The open-hearth metallurgist maintains complete records of the melting and rolling characteristics of the various heats which go into the same item, and charts the trends of any variations in practice. On particularly difficult jobs it is sometimes desirable to remove some of the more highly segregated portion of the ingot for reapplication on an item where the physical requirements are not so stringent.

In the cold reduction of the hot-rolled strip to gage, the sheet producer has another opportunity to tailor his product. He may vary the amount of cold reduction necessary to reduce the hot strip to the desired thickness within the limits of the capacities of the hot-strip mill and the cold-strip mill, to produce a sheet having the physical properties that he desires. Hayes and Burns (6) have shown the variation in grain sizes that can be produced with different amounts of cold reduction up to 60 per cent, and also the variation in size after annealing at 1100 and 1350 F, which have been reproduced in Figs. 9, 10, and 11. In general, a cold reduction of at least 30 per cent is necessary if the next operation is to be a box anneal at 1200 F or higher in order to avoid the production of extremely coarse-grained material that is unsuited to any forming and drawing requirements. The effect of variations in the amount of cold reduction on the physical properties for annealing temperatures of 1100 and 1350 F is shown in Fig. 12. The sharp breaks exhibited in the curves between 5 and 20 per cent cold reduction are due to an uneven coarse grain caused by a critical degree of strain (7) before box annealing.

Fig. 9 Microstructure of Mild Steel Normalized and Cold Reduced Various Amounts

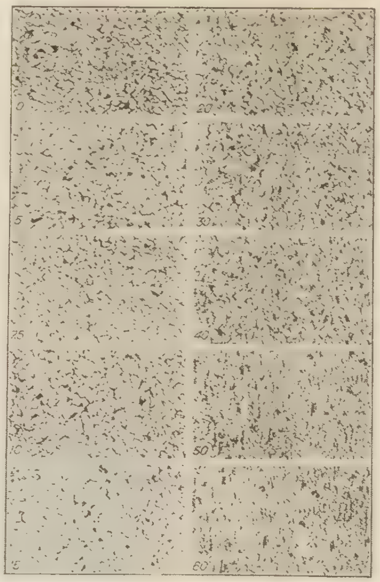


Fig. 10 Microstructure of Mild Steel Cold Reduced Various Amounts, and Box Annealed 4 Hr at 1100 F and Cooled 25 F per Hr

Fig. 11 Microstructure of Mild Steel Cold Reduced Various Amounts, and Box Annealed 4 Hr at 1350 F and Cooled 25 F per Hr

(Original magnification of ×100 has been reduced 50 per cent.)

In selecting the amount of cold reduction to be used, the sheet-mill metallurgist is governed by a number of factors, among which are: (a) The severity of the drawing operation; (b) the surface requirements, both in the severely strained and undisturbed areas of the stamping; (c) the analysis of the steel to be used; (d) the annealing cycle to be used; and (e) the mechanical limitations of the hot- and cold-strip mills. Usually the figure arrived at by weighing all of the different factors is somewhere between 30 and 70 per cent.

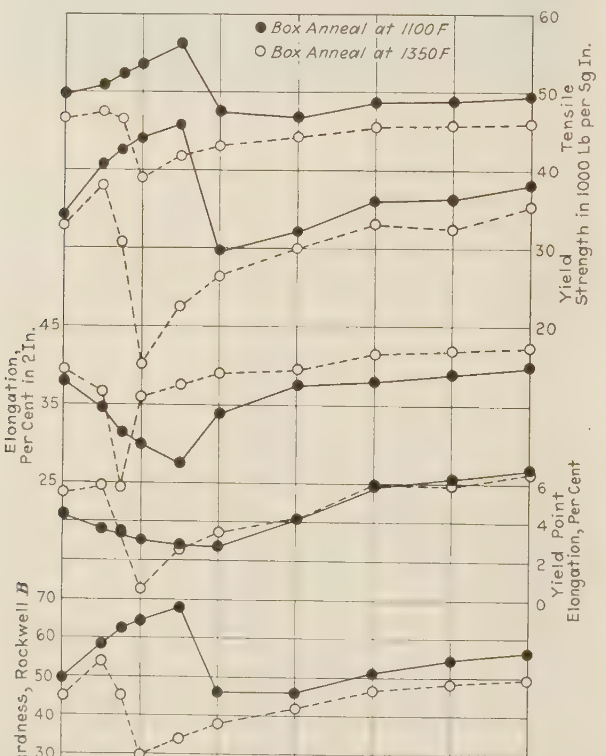


Fig. 12 Physical Properties of Mild Steel Cold Reduced Various Amounts and Box Annealed at 1100 and 1350 F

In the most modern methods of processing, sheets which have been cold reduced in excess of 30 per cent are usually annealed in a stationary box-type of in-and-out furnace in heavy packs, or if the newest development of box-annealing equipment is used, it would more properly be termed a box-type on-and-off furnace. The newest construction of box-annealing furnaces utilizes a number of bases on which the charge is built. After covering the charge in a suitable manner, the heating unit is lowered over the covered charge and fired until the heating and soaking cycle has been completed. Then it is lifted off and removed to the next charge to be annealed. For very wide and long sheets, the charge may be as much as 50 to 75 tons. The annealing is carried out under closely controlled conditions, usually automatic, and with elaborate precautions to see that no part of the charge is overheated while the coldest part is coming up to temperature. A protective gas atmosphere is added under the cover to prevent the sheets from scaling during the cooling cycle. The temperatures ordinarily used are from 1250 to 1350 F, depending on the fabrication to be performed, the steel that is being used, and the efficiency of the separating medium on the sheets to keep them from welding together at the annealing temperature. Fig. 13 shows a charge of sheets with thermocouples placed before covering. Fig. 14 shows the automatic control system that is used to insure the proper rate of heating and time of soaking to produce a thorough and uniform annealing of the charge.

In the older process of hot rolling to finished gage, the sheets were invariably normalized to recrystallize and refine the grain structure, thus erasing the variations from the hot-mill rolling. If these sheets were to be box annealed as the cold-reduced sheets are, the grain size would be extremely nonuniform and the physical properties very poor since the amount of strain

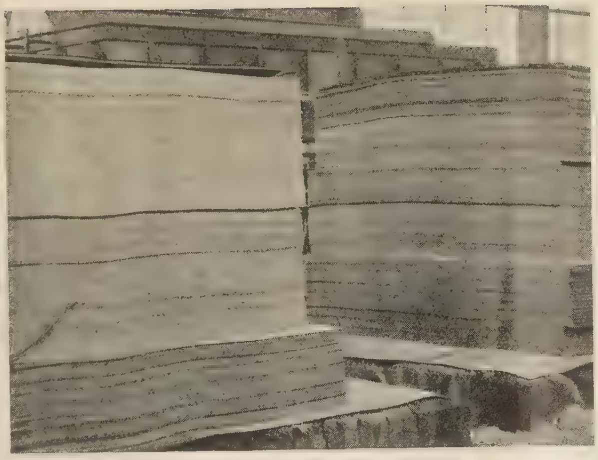


FIG. 13 MILD-STEEL SHEETS BUILT FOR BOX ANNEALING WITH THERMOCOUPLES IN PLACE

FIG. 14 AUTOMATIC RECORDING INSTRUMENTS USED TO CONTROL THE BOX-ANNEALING CYCLE

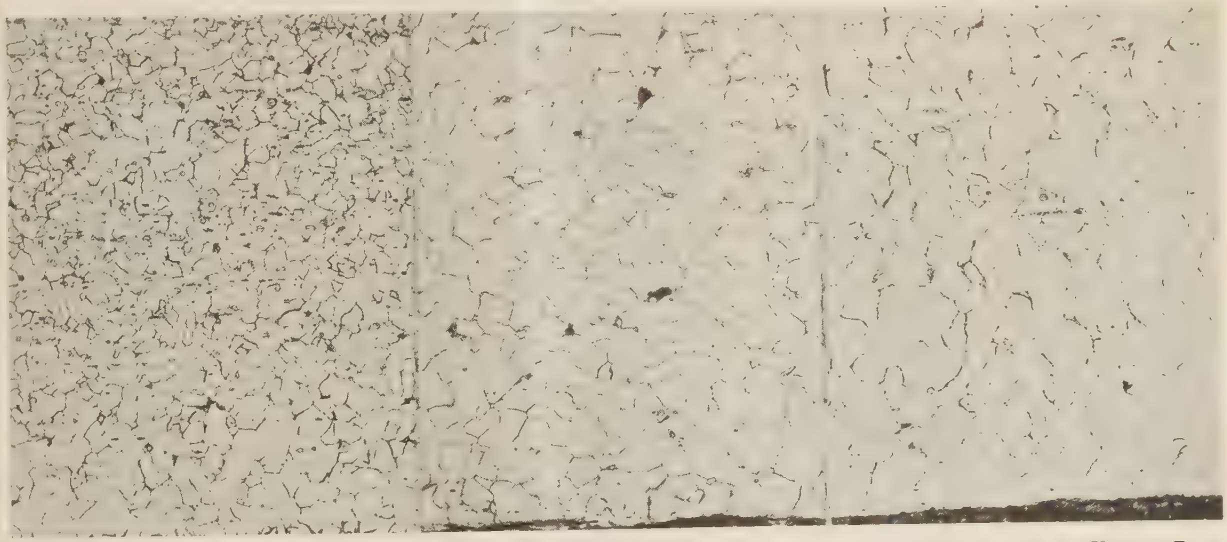


FIG. 15 TYPICAL GRAIN STRUCTURE OF NORMALIZED MILD-STEEL SHEETS COOLED FROM NORMALIZING TEMPERATURE AT VARIOUS RATES
(Left: Cooling rate 185 F per min. Center: Cooling rate 44.5 F per min. Right: Cooling rate 30 F per min. Magnification ×100.)

remaining in the sheets after the hot-rolling operation is in the critical-strain (7) range for low-carbon rimming steel. The hot-rolling operation in wide sheets is not nearly so susceptible to close control as it is on narrower sheets in so far as residual strain in the sheet is concerned. This is because on wide sheets the hot-mill roller must be allowed sufficient latitude in his heating temperatures so that he can coordinate the shape of his mill, the drafts he must take, the shape of his breakdowns and other factors, in order that he can produce a sheet of sufficient length to shear out and be free from surface defects such as pinchers, jumpers, and scale matte. The magnitude of these variables is decreased considerably in rolling narrow sheets, and conditions can be controlled to such an extent that these sheets can be box annealed without encountering critical grain growth. The manufacturer who hot rolls wide light-gage sheets has at best a most difficult task to produce the required tonnage with nominal scrap even when taking full advantage of the latest mechanical developments in hot-mill heating and rolling equipment.

In the normalizing operation, the sheet producer has another opportunity to tailor his product according to the customer's demands. He has the opportunity to vary his normalizing temperatures and heating and cooling rates. The effects of such variation on grain size are shown in Fig. 15. In general, the slower the cooling rate, the larger the resulting grain size will be. While most of the product that is normalized is rolled on a hot mill, cold-reduced sheets may be normalized when it is so desired (and such is often the case, even with the additional expense involved). Cold-reduced sheets which have been normalized are in general slightly finer grained and harder than the hot-rolled product, when the normalizing cycle is the same. A comparison of the hardness of hot-reduced and cold-reduced normalized sheets is shown in Fig. 16. These data have been plotted in the form of curves showing the cumulative percentage of tests below any given hardness within the range of tests. The width of the range is in a large part due to segregation effects in the ingot. The metallurgical department patrols this operation very closely, making a great number of tests from which distribution curves are drawn for varying furnace practices and analyses. The control is then worked on a method of extremes and averages, inasmuch as the range of hardness is somewhat wide on any one

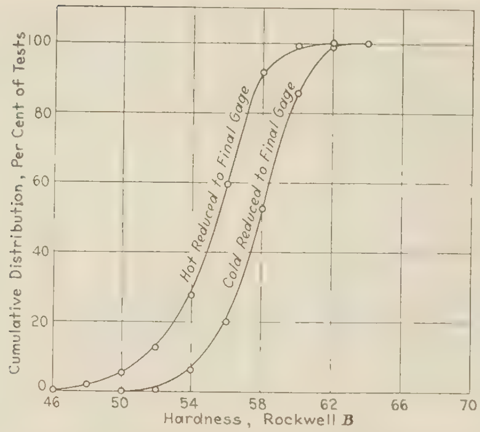


FIG. 16 EFFECT OF METHOD OF ROLLING ON ROCKWELL HARDNESS AFTER NORMALIZING

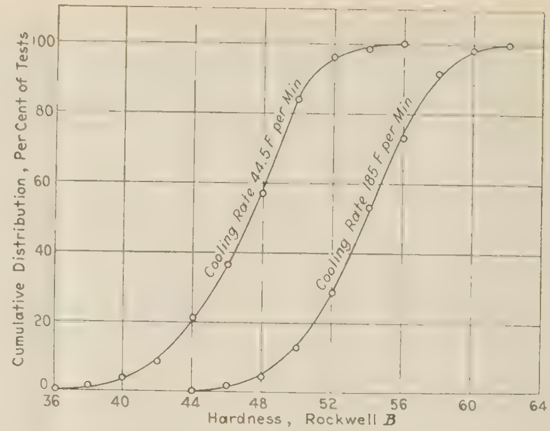


FIG. 17 EFFECT OF RATE OF COOLING FROM NORMALIZING TEMPERATURE ON THE ROCKWELL HARDNESS OF MILD-STEEL SHEETS

heat due to the segregation effects in the ingot. Another such curve is shown in Fig.17 which shows the effect of a variation in cooling rate on the cumulative distribution of Rockwell-hardness values.

After the normalizing operation, the sheets are pickled to remove scale, temper rolled a specified amount on smooth rolls to improve the surface and flatness, and then reannealed to remove the cooling strains from normalizing and also the strains from the temper rolling. This annealing is carried out in box-type in-and-out furnaces similar to those referred to in the anneal-

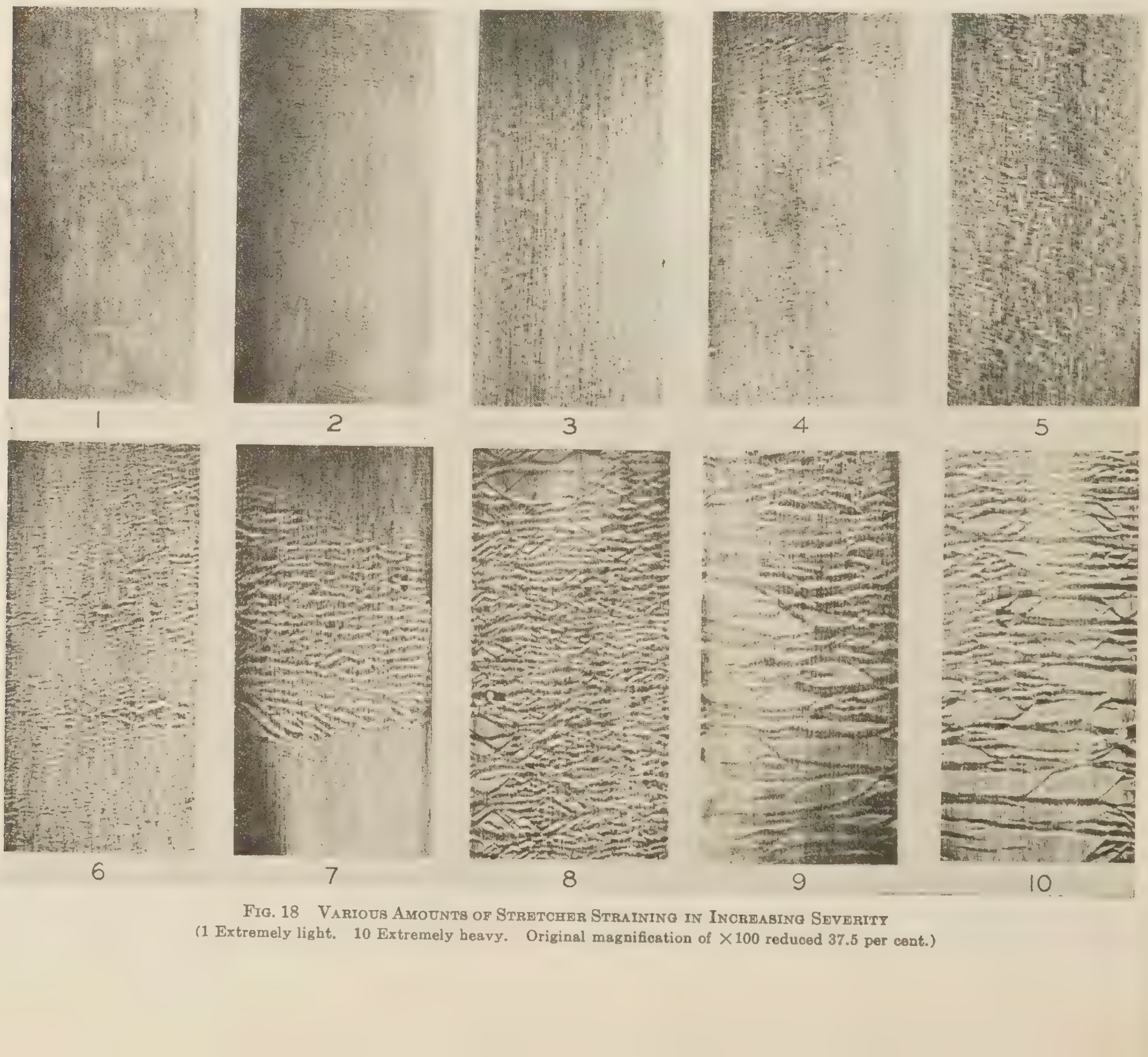


FIG. 18 VARIOUS AMOUNTS OF STRETCHER STRAINING IN INCREASING SEVERITY
(1 Extremely light. 10 Extremely heavy. Original magnification of $\times 100$ reduced 37.5 per cent.)

ing of cold-reduced material, and the same precautions are taken in heating the charge. The annealing temperature used to relieve the strains varies from 950 to 1200 F, depending on the requirements of the customer's fabrication.

After the sheets from either process have been box annealed, they are ready for temper rolling or the pinch-pass operation where the metallurgist has his final opportunity to control the results that will be had in the drawing operation. Sheets have their maximum ductility and minimum hardness after annealing, and it is extremely unfortunate that they cannot be drawn in this condition without objectionable surface disturbances taking place. These surface disturbances are known as "stretcher strains," "worms," or "Luders lines" and are intimately connected with the elongation that takes place at the yield point when a tensile sample is stretched. Fig. 18 shows the appearance of these stretcher strains. The yield-point elongation of well-made sheets or strip in the annealed condition is usually within the range of 3 to 7 per cent and can be completely removed by temper rolling (pinch passing); and when completely removed, the material no longer shows these characteristic surface disturbances. This subject has been covered intensively in a number of papers (8, 9, 10) and will only be considered briefly here. Two of the factors with which the yield-point elongation of annealed mild-steel sheets is related are:

1 Ratio of the yield point to tensile strength (often termed "elastic ratio"): The lower the elastic ratio, the lower the yield-point elongation.

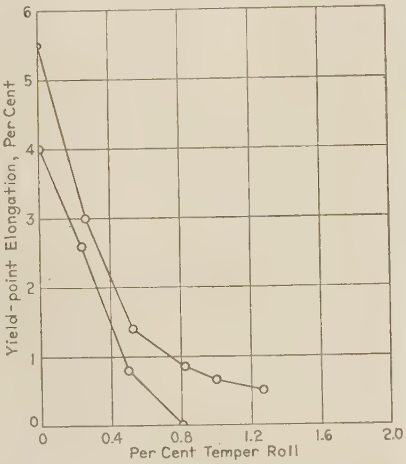


Fig. 19 Effect of the Amount of Yield-Point Elongation as Annealed on the Amount of Temper Rolling Necessary to Eliminate the Yield-Point Elongation. Temper Rolling Done With 4-In. Diameter Rolls

2 Grain size: Generally, the finer the grain size, the greater the yield-point elongation.

The amount of temper rolling necessary to remove the yield-point elongation completely is directly proportional to the yield-point elongation of the annealed material (6). This relationship is shown in Fig. 19.

Unfortunately, temper rolling, while eliminating the yield-point elongation and also the corresponding tendency to stretcher strain when performed in increasing amounts, also increases the

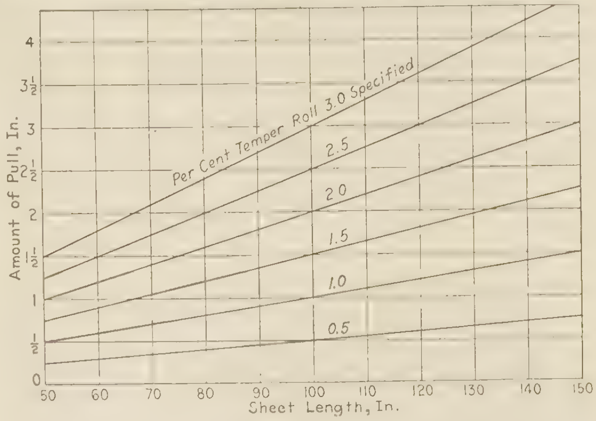


Fig. 20 Cold-Roll Chart for Temper Rolling

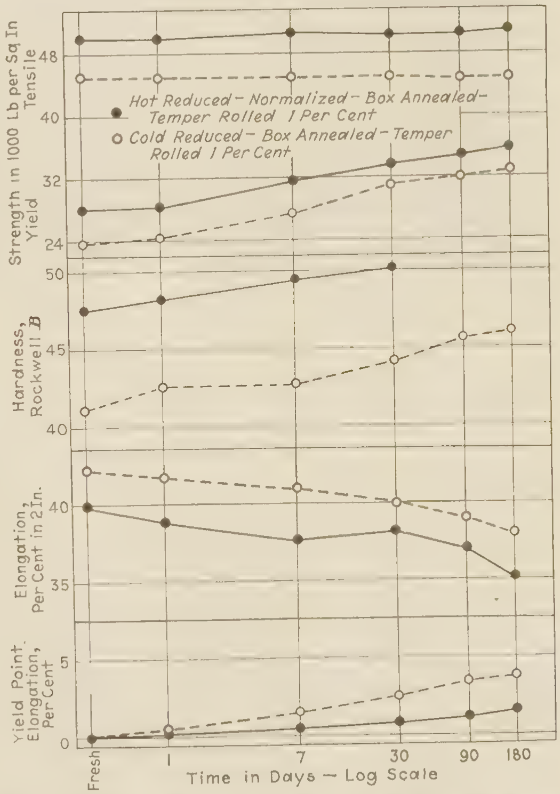


Fig. 21 Effect of Time on the Physical Properties of Mild-Steel Sheets

TABLE 3 EFFECT OF TIME ON THE PHYSICAL PROPERTIES OF MILD-STEEL SHEETS TEMPERED 1 PER CENT

	Hot-reduced, normalized, and annealed					Cold-reduced and annealed				
Time	Yield strength, lb per sq in.	Tensile strength, lb per sq in.	Elongation, % in 2 in.	Yield-point elongation, %	Rockwell hardness, B	Yield strength, lb per sq in.	Tensile strength, lb per sq in.	Elongation, % in 2 in.	Yield-point elongation, %	Rockwell hardness, B
Fresh	28000	49950	39.9	0.0	47.6	23770	45120	42.2	0.0	44.1
1 day	28400	50000	38.9	0.2	48.3	24450	44750	41.8	0.4	42.6
7 days	31860	50470	37.7	0.5	49.4	27600	44350	41.0	1.5	42.8
30 days	33670	50460	38.3	0.8	50.1	31210	44980	40.0	2.5	44.1
90 days	34770	50530	37.0	1.2	..	32030	44400	39.0	3.4	45.6
180 days	35940	50960	35.2	1.6	..	32750	44900	38.0	3.8	46.0

hardness and decreases the ductility. Still more serious, it sets off the aging tendency (10) which further deteriorates the physical properties with time. Under these conditions, it is customary in the mill to temper roll an amount slightly greater than the minimum amount necessary to prevent the sheets from stretcher straining when used within a reasonable period of time and not so much as would cause an extensive increase in breakage in the drawing operation.

The amount of temper is customarily specified as a certain percentage of elongation of the annealed sheet. Charts, an example of which is shown in Fig. 20, have been prepared from which the temper roll operator can rapidly determine the actual elongation in fractions of an inch to be applied to the sheet. The percentage temper rolling will usually be in the order of from 0.3 to 3 per cent. Measurements are taken throughout the lift of iron being rolled by temper-roll checkers attached to the metallurgist's staff to insure the proper temper being applied. On wide sheets it is customary to measure the elongation on both sides and also in the middle to be sure that the mill is pulling straight, since a variation in pull of as much as 1 per cent between the two sides of a sheet 63 in. wide will not be apparent as readily in the form of camber as it would be on a sheet only 30 in. in width. With close control it is possible to temper roll wide sheets as close as plus or minus 0.1 per cent of the specified amount.

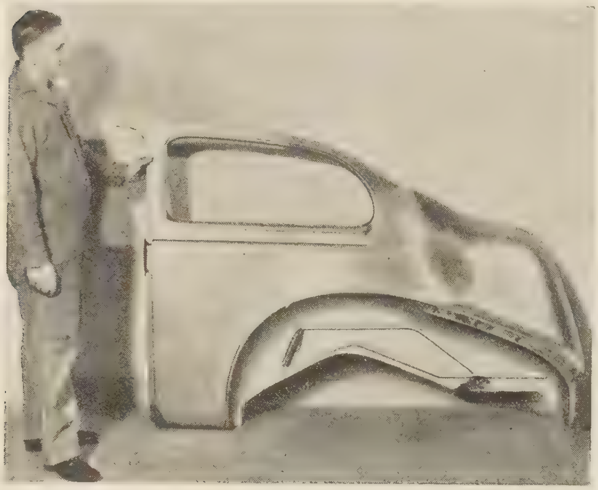


Fig. 22 A Finished Quarter-Panel Ready for Application to an Automobile Body—Archer and Geuder (11)

After temper rolling has been completed, the sheets are inspected, packed, and shipped. If the fabricator uses the sheets promptly after their arrival, a minimum of difficulty can be expected in so far as changes due to aging are concerned. The magnitude of the deterioration in physical properties experienced with time (aging) on tempered drawing sheets is given in Table 3 and the trend is shown in Fig. 21. In addition to the hardening action and loss of ductility, the yield-point elongation also comes back with the resultant difficulties associated with surface disturbances such as stretcher strains.

We have dealt with the manufacture of wide sheets by several different processes, of which the essential difference, in so far as metallurgical characteristics are concerned, is in the manner in which the sheets have been reduced to gage and then annealed. Aside from economy and improved surface, the most modern practice of cold reduction to gage followed by annealing has another great advantage over the older processes requiring both normalizing and annealing. This advantage is in the improved physical properties that are obtained by the most modern method. A typical comparison of these differences may be observed by referring to Table 3.

It will be noted that the yield strength, tensile strength, and hardness of the cold-reduced annealed sheet are lower and the percentage of elongation in 2 in. has been increased to the extent of approximately 2.5 per cent. In addition, the metal has less tendency to buckle in the dies and to spring back when removed from the dies due to the initially lower yield point which allows flow into the dies at lower unit stresses than with initially harder and tougher material. The principal disadvantage with cold-reduced annealed sheets is their increased tendency to stretcher strain after short periods of aging as compared to a normalized box-annealed sheet.

Application of Wide Sheets in the Automobile Body

The developments in the utilization of wide cold-rolled drawing sheets in automobile-body and fender fabrication have been published by Winlock and Kelley (9), Archer and Geuder (11), and Beaudoin (12). From 1928 to the present time it has been the problem of the steel mills to give to the automotive industry all of the wide sheets that they required. It was formerly the practice to make the rear quarter of an automobile body in a

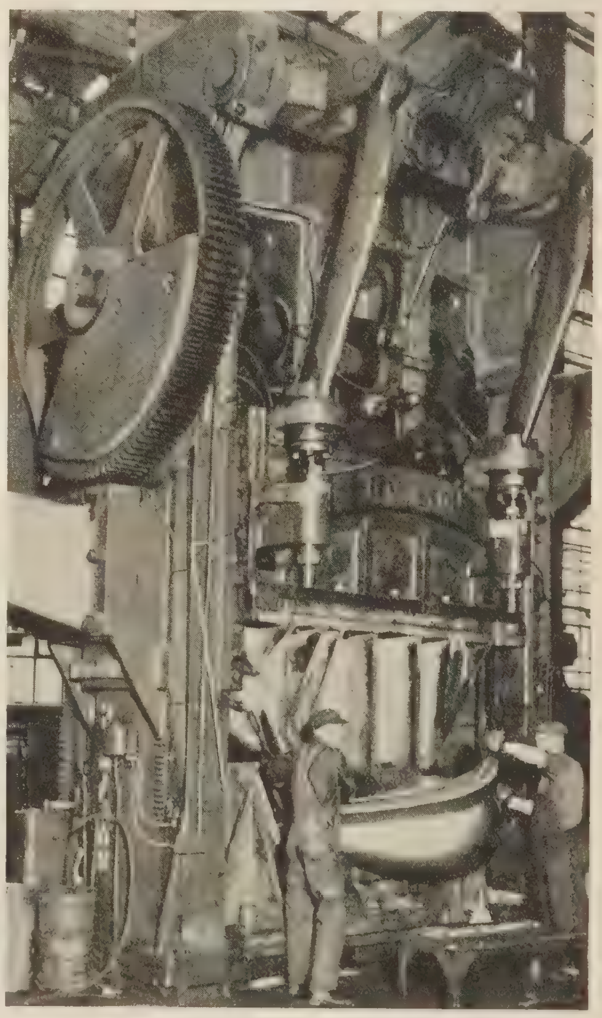


Fig. 23 Drawing a Buick Front Fender—Beaudoin (12)

number of stampings, such as the upper quarter-panel, the lower quarter-panel, the wheelhouse panel, and roof rail, which were fastened together in various manners, most often by welding, and the joints covered with decorative trim. Present practice is to use wide sheets and eliminate as many welds and operations as possible as is evidenced by the single stamping now being used for a rear quarter-panel, an example of which is shown in Fig. 22. In some plants a complete side panel for the body is made in one stamping.

Fenders which were formerly made with a crown and apron, are now being made in one piece as shown in Fig. 23, which also includes the hood ledge. Another notable new use of wide sheets is in the one-piece drawn-steel top, shown in Fig. 24, which was pioneered by Fisher and is now practically standard equipment on closed cars throughout the automotive industry. Not many

Fig. 24 Turret Automobile Top Ready to Be Welded to a Complete Body. There Are Only Four Points at Which This Top Is Welded to Additional Panels—Archer and Geuder (11)

years ago such a stamping would have been impossible both from a sheet and press standpoint unless it had been assembled from a number of smaller stampings.

Another present-day trend in the automobile-body-fabricating industry is toward the use of "sheets in coils," or wide-strip coils, in order to blank irregular shapes with greater economy, in so far as scrap is concerned, than would be possible from rectangular sheets. Parts being made from wide coils now include side panels, radiator shells, front and rear fenders, hood tops, hood sides, and running boards.

As is usual in cases where rapid progress has been made, the art in many cases has preceded the science, and were it not for the wholehearted cooperation of the body fabricators and stamping shops, it is quite doubtful whether the development of wide drawing sheets would be as far along as it is at the present time. The installation of processing levelers of the Budd-McKay type has been very helpful in the utilization of sheets having a tendency to stretcher strain, which might have been due to slightly undertempering at the mill or to the effects of aging.

It is general sheet-mill practice to have mill representatives and metallurgists frequently contact the sheet-consuming industries so that any slight adjustments that are required in the sheet-production methods can be made as the need arises. This enables the mill to clearly understand the customers' requirements and make changes in processing of material to meet specific requirements. In most cases the cooperation between the consumer and the mill has been so complete and satisfactory that it has been found unnecessary to write restrictive purchasing specifications covering the physical properties and chemistry of the sheets, the main requirement being that the sheets should be satisfactory for the job in so far as breakage, surface after drawing, and bad metal is concerned. Bad metal includes such surface defects as slivers, fins, pits, and scratches which might develop only after the sheet has been drawn.

The sheet manufacturers will and are continuing to cooperate with the users of sheets to meet new requirements and to improve the present products. There is a large amount of work still to be done in the steel plant and rolling mill in the matter of making better drawing sheets. Particularly are there opportunities along the line of decreasing, or preferably, completely eliminating, the aging behavior which always develops if there is any abnormal delay in stamping sheets after they have been delivered. The very nature of the steel used in the production of sheets for drawing purposes at the present time makes this a rather difficult undertaking, but that the problem is not insurmountable has been demonstrated.

Acknowledgments

The author takes this opportunity to express his indebtedness to The American Rolling Mill Company for making available their facilities and also much of the data incorporated in this paper.

BIBLIOGRAPHY

1 "New High Peak in American Steel," *Iron Age*, vol. 119, January 6, 1927, pp. 1–9.

2 "The Evolution of the Wide Strip Mill," by S. Badlam, American Iron & Steel Institute Yearbook, 1927, pp. 343–414.

3 "Present Steelmaking Facilities Show Significant Weaknesses if Rush of New Business Continues," by J. D. Knox, *Steel*, vol. 100, January 4, 1937, Table VIII, p. 116.

4 "Modern Equipment for Making Armco Strip Steel," by C. Longenecker, *Blast Furnace and Steel Plant*, vol. 24, December, 1936, pp. 1061–1066.

5 "Rolling Mills for Wide Strip," by A. Noll, *Blast Furnace and Steel Plant*, vol. 24, November, 1936, p. 993.

6 "Cold Rolling of Mild Steel Sheets and Strip," by A. Hayes and R. S. Burns, American Society for Metals, Preprint No. 12, Meeting of October 19–23, 1936, pp. 15–26.

7 "The Metallography and Heat Treatment of Iron and Steel," by A. Sauveur, McGraw-Hill Book Company, New York, N. Y., fourth edition, 1935, p. 285, et seq.

8 "Autographic Stress-Strain Curves of Deep-Drawing Sheets," by R. L. Kenyon and R. S. Burns, Transactions of the American Society for Steel Treating, vol. 21, 1933, pp. 577–600.

9 "Sheet Steel and Strip Steel for Automobile Bodies," by J. W. Winlock and G. L. Kelley, Transactions of the American Society for Steel Treating, vol. 18, 1930, pp. 241–269.

10 "Aging of Mild Steel Sheets," by R. O. Griffis, R. L. Kenyon, and R. S. Burns, presented before a meeting of the American Iron & Steel Institute, and abstracted in the following publications: *Steel*, vol. 92, May 29, 1933, pp. 23–25; *Iron Age*, vol. 131, June 1, 1933, pp. 861–862; *Blast Furnace and Steel Plant*, vol. 21, June 6, 1933, pp. 312–314, and 329.

11 "Steel Sheets for Today's Motor Car," by T. P. Archer and R. A. Geuder, *Iron & Steel Engineer*, vol. 13, December, 1936, pp. 28–38.

12 "An Unusual Fender Job," by J. Beaudoin, *Metal Progress*, vol. 29–30, December, 1936, pp. 59–64.

A Study of Lip Clearance on Twist Drills

By CHARLES J. STARR,[1] URBANA, ILL.

This paper discusses the form of the warped surface on twist drills called "lip clearance" as produced by five makes of drill-sharpening machines. Theoretically this lip-clearance angle should increase as measured from the circumference toward the center of the drill. So-called correct angles are assumed for various-diameter drills with a given feed, and illustrations show how much the drills actually vary from the correct angles. The contour of the lip-clearance surface is measured by a special measuring machine.

The drills are rotated by 10-deg increments and the dial-indicator pointer on the measuring machine moved a definite distance from center for each measurement. Thus, deviations of the surface from a true cone are measured. The angle is easily computed from these data. Detailed description shows how the lip-clearance surface is developed and a comparison is made of the actual with the assumed correct angle of clearance. Figures show the developed surfaces of $^3/_8$-in. and 1-in. drills as sharpened on these five drill-grinding machines. Some drills have beveled corners and a negative clearance may be noted on these because of lack of care in sharpening the drills. The developed surface of a drill with a thinned web shows how the possibility of rubbing back of the cutting edge in the web may be reduced.

The figures show that too much clearance is ground near the circumference of the drill in most of the cases studied. A few, however, approach quite near to the so-called correct angles.

The drills are tested on drill presses equipped with dynamometers in annealed cast iron at approximately 60 fpm surface speed. Torque and thrust curves are plotted to show the power required to operate these drills. Considerable variation will be noticed in the torque and thrust. The advantage of thinning the web is brought out quite positively in these curves. The paper suggests a future study to endeavor to ascertain if one machine sharpens drills that are better adapted for drilling one material than another, also that endurance tests should be run to test the life of drills between grinds. There is no intention to criticize the design of the various sharpening machines, but rather their operation.

THE SUBJECT of twist drills has been of considerable importance for a number of years, and many studies have been made. Most of these studies have dealt with characteristics of drills other than lip clearance, and a study of this feature has not been touched upon very much as far as the author has observed.

The shape of the lip clearance is of prime importance because it helps to form the cutting edge. An excess of clearance weakens the cutting edge. If, on the other hand, there is not enough clearance the drill cannot cut freely.

"Lip-clearance angle" is a term that may require defining, and for that reason, reference is made to Fig. 1 showing the end and side views of the point of a twist drill. The term "lip-clearance surface" is given to that surface which is so named in the plan view in Fig. 1. It is the surface directly back of the cutting edge or lip, and is the peculiarly warped surface that forms the clearance between the drill proper and the bottom of the hole that has been created by the drill.

[1] Associate in Mechanical Engineering, University of Illinois. Mem. A.S.M.E. Professor Starr has served as toolmaker with the Stanley Works, New Britain, Conn., toolmaker, die maker, and toolroom foreman with the New Britain Machine Company, New Britain, Conn.; tool designer with Pratt & Whitney Company, Hartford, Conn.; and later as planning engineer with the New Britain Machine Company. These positions were held at various times between 1908 and 1921. In 1921 he became assistant superintendent of the machine laboratory at the University of Illinois, and while thus employed studied for a B.S. degree in industrial education, which he received in 1933. In 1931 he was made instructor in mechanical engineering at the University of Illinois, and advanced to his present position in 1934.

Contributed by the Machine Shop Practice Division for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until June 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Object of Study

The object of this study is to obtain the contour of the lip-clearance surface as developed by various machines that are manufactured for sharpening twist drills. As is already known, it is necessary that the angles of clearance change as the drill is measured from the circumference toward the center, along the cutting edge.

The drill illustrated in Fig. 2 shows the feed per revolution. If the circumference of the drill is developed, a triangle is formed in which the circumference forms the base of the triangle, and the feed one side. The hypotenuse of the triangle gives the helix angle of feed of the drill, or in this case, angle AOB. Now as the diameter is reduced, and the center of the drill is approached, the feed remaining constant, the angle will increase until a condition is reached that will be considered as giving the angle $A'OB$. In this case, the circumference of the circle would be $B'O'$, instead of BO, as in the first instance. Thus, it is seen that the angle of clearance, or the form of the lip clearance, must change and become greater toward the center of the drill than near the circumference. The variations observed resulting from the measurement of this lip clearance led to the present discussion.

Method of Measuring

The method developed for measuring the lip-clearance angle led to the construction of the machine shown in Fig. 3. This apparatus consists primarily of a means of holding the drill and revolving it any number of degrees desired. A pointer comes in contact with the lip clearance of the drill and the drop of that face from a true cone is measured in thousandths of an inch.

A drill lined off to illustrate the circular and radial movements of the indicator pointer is shown in Fig. 4. By means of the compound rest on the measuring machine, it is possible to get the line of travel of the dial indicator parallel to the cutting edge of the drill.

When the drill is inserted in the collet in the headstock, it is rotated until the cutting edge stands in a horizontal position as is shown in Fig. 5A. This position is checked with a horizontal

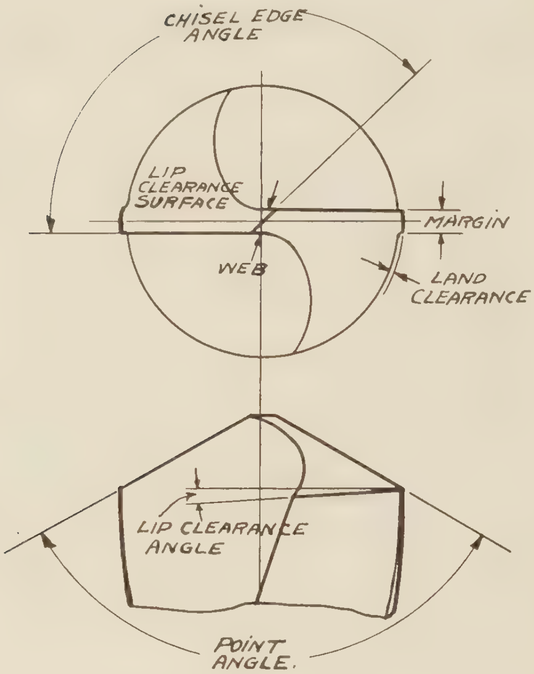


Fig. 1 The Drill With Parts Defined

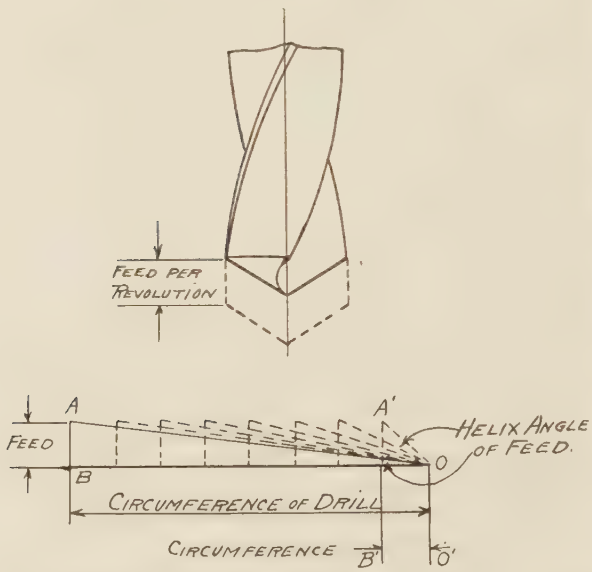


Fig. 2 Designation of Feed and Change in Helix of Feed

straightedge and a magnifying glass. A graduated dial at the left end of the headstock is then set at 0. The chisel-edge angle, such as 138 deg shown in Fig. 5*G*, is then determined by rotating the drill.

When operating this machine, the point of the indicator is set on center, both vertical and horizontal, with the center of the headstock of the spindle. By rotating the screw of the compound rest, the indicator, or point, travels along the face of the drill, from the center toward the circumference or from the center of Fig. 5*A* along the center line *BA*, from its center toward *A*. Thus, it is possible to find the point angle as shown in Fig. 5*F*, that is, angle 124 deg 20 min in this case.

The next step is to measure the angle of clearance. Fig. 5*A* shows how the drill is rotated with the indicator point set any desired distance from the center of the drill. As the pointer is moved by $^1/_{64}$-in. increments along radii from the drill center, the drill is rotated clockwise, for readings below center line *AB*, and counterclockwise for readings above center line *AB*. To explain this more thoroughly, take one increment and follow it through to obtain the measurement desired. Consider the radius of the circle as that shown by the line *O* to *C* in Fig. 5*F*, and divide this distance up into sixty fourths as shown in Fig. 5*A* and 5*B*. The divisions are represented by the various circular lines shown of these two figures. If the $^1/_8$-in. circle is considered as an example, the circular line XY shown in Fig. 5*A* will represent that part of the circle which passes over the clearance surface of the drill, *X* representing the point where the circle passes through the cutting edge, and *Y* the point where it intersects the flute of the drill.

If a cylinder with $^1/_8$-in. radius, having its axis coincident with that of the drill, is passed through the clearance face, it will cut it as shown in Fig. 5*F* where the cylindrical surface *PQ* cuts the clearance face, and will be the segment of a circle *XY* as shown in

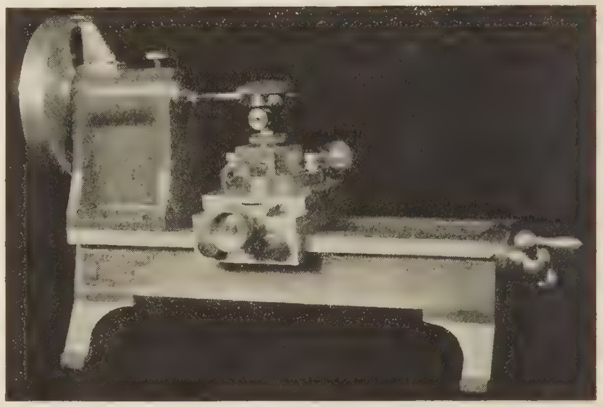


Fig. 3 Machine for Measuring Lip Clearance

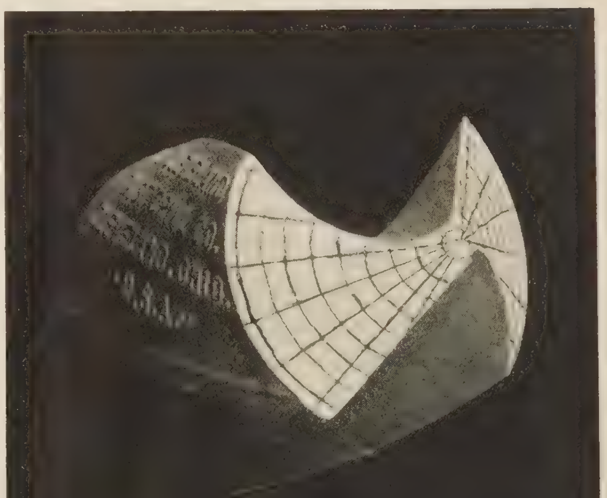


Fig. 4 Enlarged Point of Drill Lined off to Illustrate Circular and Radial Movements of the Indicator Shown in Fig. 3

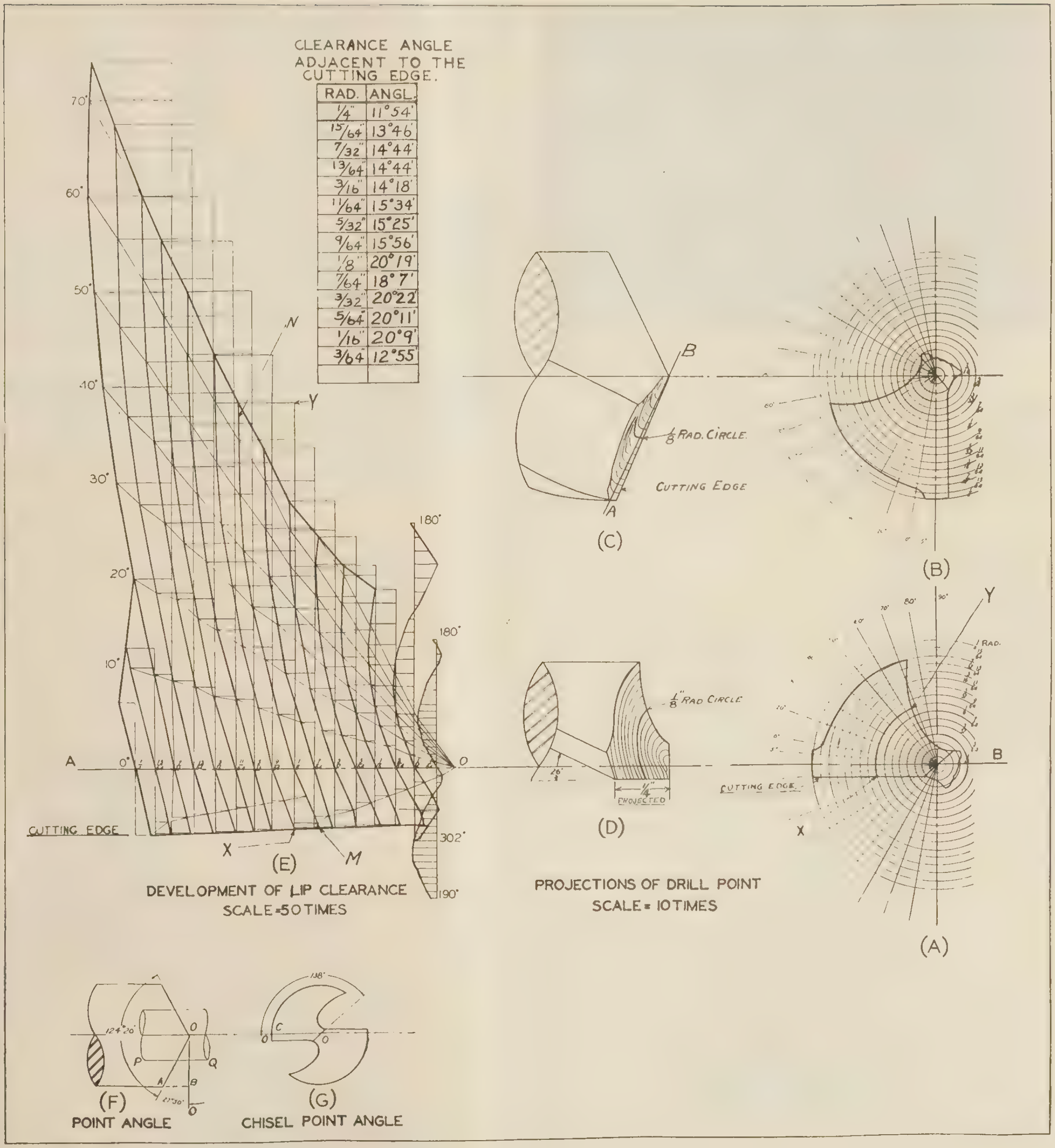


FIG. 5 STUDY OF LIP CLEARANCE OF 1/2-IN. TWIST DRILL

Fig. 5*A*, but as this intersection is looked at from a different angle, it will appear as shown in Fig. 5*D*. It appears as an irregularly curved line, with relation to the cutting edge, because the end of the drill is not a true cone, due to the clearance ground on it.

As the surface drops away from the cutting edge, the distance from the true cone to the clearance face will increase with the result that a peculiar curve is shown by a 1/8-in. radius circle shown in 5*D*. The distance between the true circle and the irregular curve, shown in Fig. 5*D*, is measured on the dial indicator, as the drop or clearance of the cutting edge for any given distance.

To show this drop, that is, the form of the lip-clearance angle and its deviation from a true cone, the surface is developed as is shown in Fig. 5*E*.

In Fig. 5*F* it will be found that the triangle *AOB* has *AO* as the cutting edge of the drill and *BO* as the radius. Therefore *AB* is the projection of *AO* on the line *AB*, and the distance called 1/4 in. in Fig. 5*D* is this projection. Since this particular drill is 1/2 in. diameter and the cutting edge is to be measured by 1/64-in.

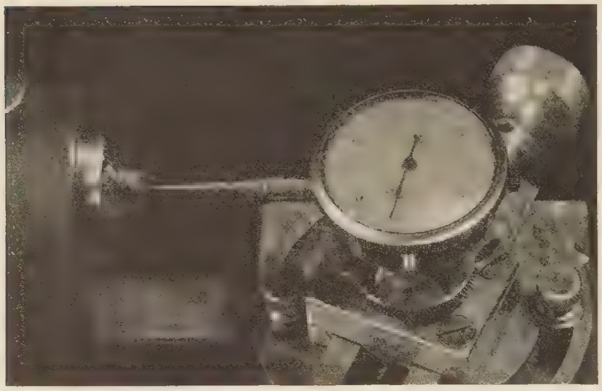


Fig. 6 A Drill Being Measured for Clearance

increments, the line AB in Fig. 5F is divided accordingly. That part of the circle as shown by XY in Fig. 5A is developed and now appears as a straight line XY in Fig. 5E, and the clearance is represented by the heavy line MN. The other light lines in Fig. 5E show the construction, how the distance changes by 10-deg increments, and how the angle of clearance forms a curve, and not a straight line.

TABLE 1 DRILL FEEDS USED IN PRACTICE, AND AVERAGE FEEDS USED BY THE AUTHOR IN THIS PAPER

Drill diameter, in.	Feeds used in practice, in. per rev Minimum	Maximum	Feeds assumed as average by the author, in. per rev
1	0.014	0.050	0.040
3/8	0.008	0.013	0.012
5/16	0.007	0.012	0.010
1/4	0.006	0.010	0.008
3/16	0.005	0.007	0.006
1/8	0.004	0.006	0.005

When reading the dial indicator, as the drill is measured, those values that occur to the right of zero on the dial shown in Fig. 6 are considered as plus and those to the left of zero are considered as minus. This method of designation is used as a convenience when laying out the developed view as shown in Fig. 5E. Plus values are placed to the left of the vertical line and minus values to the right.

It is also possible to notice that the angle of clearance at the circumference C is less than the angle of clearance near the center. The table accompanying Fig. 5 shows the clearance angle at a distance approximately equal to 10 deg back from the cutting edge. Drills ground on five types of drill grinders were measured in the manner just described.

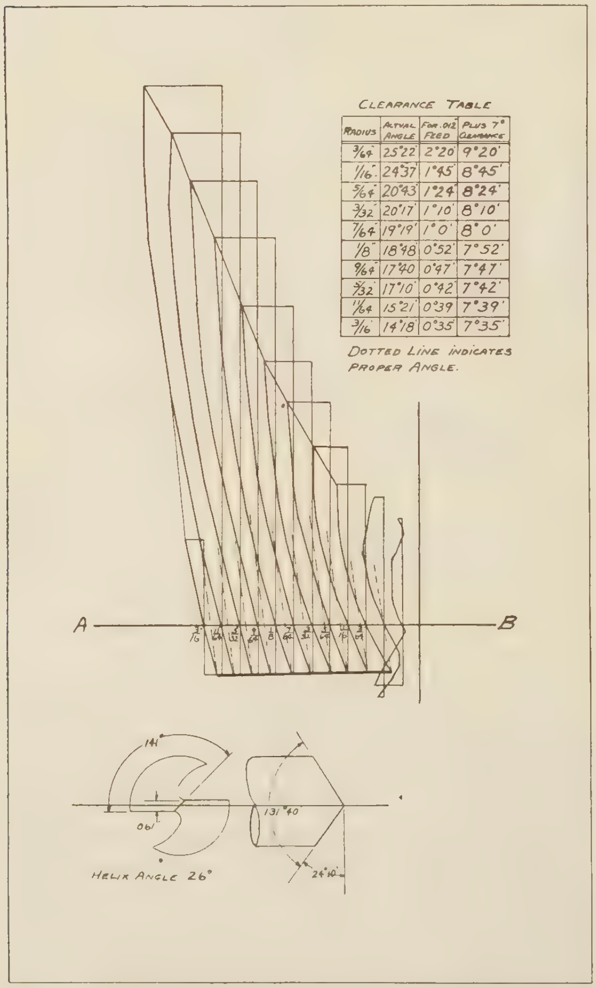


Fig. 7 Point Study of 3/8-In. Drill Sharpened on Machine A

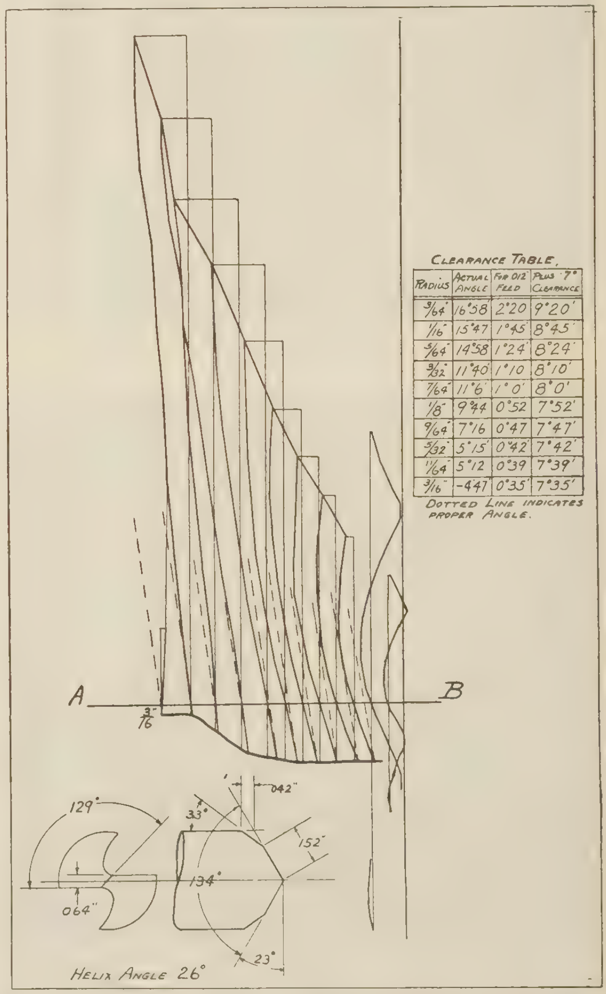


Fig. 8 Point Study of 3/8-In. Drill Sharpened on Machine B

The Angle of Feed

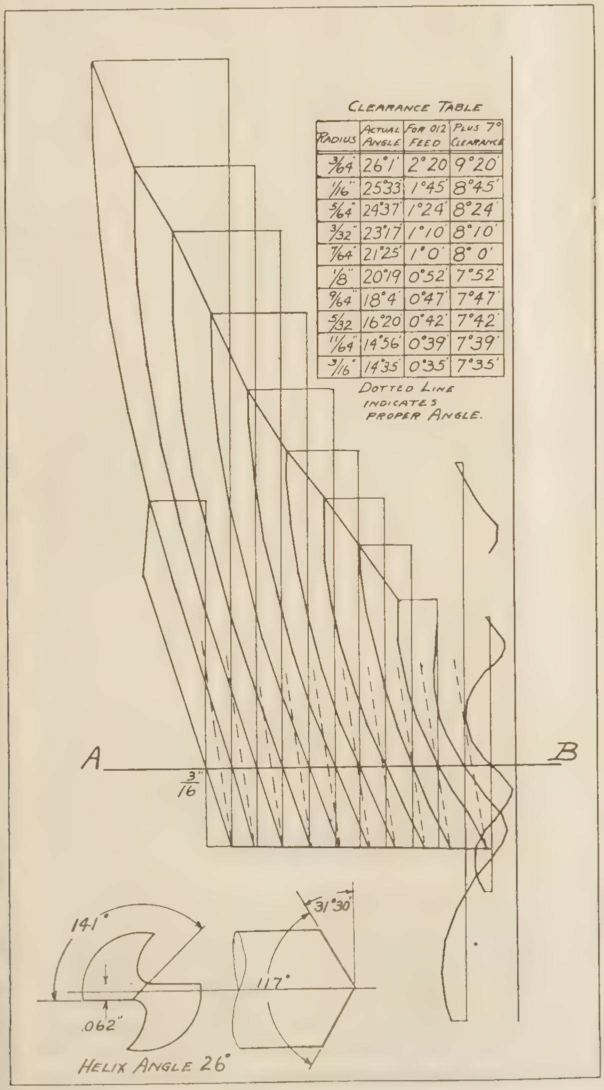
The question which immediately presents itself is: "What should be the correct angle?" It is necessary that one should know before this question is answered what the correct feed is for any given size drill? Apparently, a standardized feed for a given drill is impossible, because of varying conditions of machine and material, as well as quality of the drill. Therefore, as a basis on which to work, it is necessary to assume given feeds for given size drills. For this purpose, the author took feeds for these given size drills from the actual practice of various users and drill manufacturers, and from the data gathered assumed an average feed, which average feed is used throughout the remaining part of this paper. The feeds used in practice as obtained from users and manufacturers of drills, together with the average feed for each size of drill as assumed by the author, are given in Table 1.

Helix angles were developed from the author's assumed values of feeds by the method shown in Fig. 2. The feed specified for a given diameter of drill and the angle was figured from the circumference to the center for changes in diameter by $^{1}/_{32}$-in. increments. The results obtained from these drills, sharpened by different methods, are extremely interesting.

Developed Curves

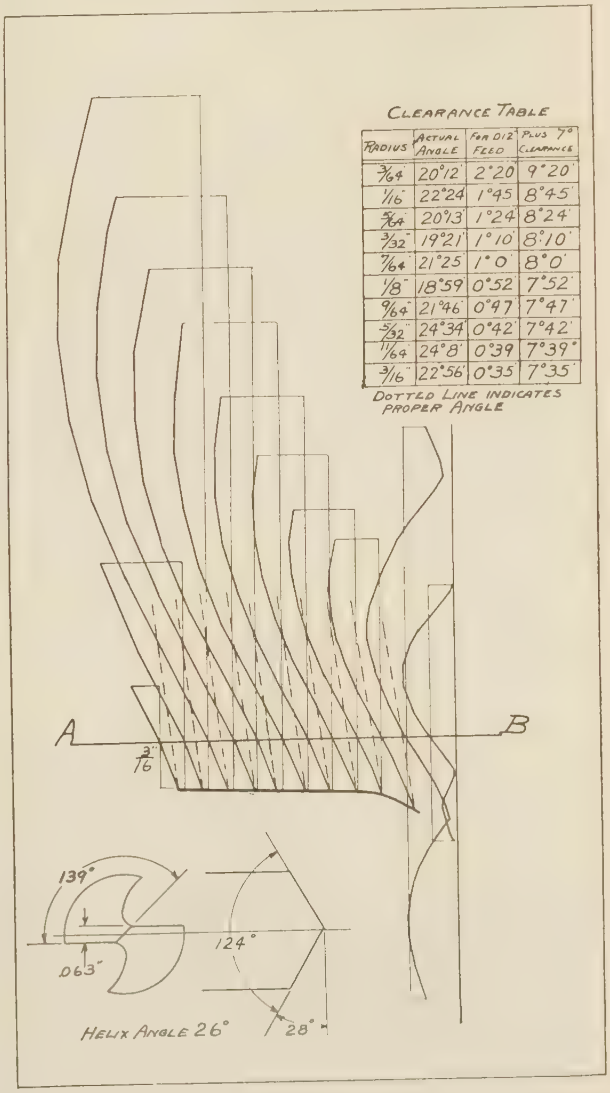
In Figs. 7, 8, 9, and 10 are shown studies of the points of $^{3}/_{8}$-in. drills ground on four different types of machines, hereafter designated as machines *A*, *B*, *D*, and *E*. A clearance table is included with each figure which shows the actual clearance by $^{1}/_{64}$-in. increments from the center to the circumference as compared with the feed angle required for the feed for that given diameter, the feed being the author's assumed values given in Table 1. Of course, it must be realized that clearance above the angle of feed must be maintained so that the cutting edge will clear and actually cut. For that reason, a clearance angle of 7 deg has been arbitrarily assumed, and this angle, added to the angle of feed, appears in the fourth column of the table shown with each of these figures. The dashed lines in each figure indicate what may be assumed to be the proper angle.

It may be observed, after examining these figures, how much the actual cutting angle differs from that which is required in



Radius	Actual Angle	For 012 Feed	Plus 7° Clearance
3/64"	26°1'	2°20	9°20'
1/16"	25°33'	1°45'	8°45'
5/64"	24°37'	1°24'	8°24'
3/32"	23°17'	1°10'	8°10'
7/64"	21°25'	1°0'	8° 0'
1/8"	20°19	0°52'	7°52'
9/64"	18°4'	0°47'	7°47'
5/32	16°20'	0°42'	7°42'
11/64"	14°56'	0°39'	7°39'
3/16"	14°35'	0°35'	7°35'

Fig. 9 Point Study of $^{3}/_{8}$-In. Drill Sharpened on Machine *D*



Radius	Actual Angle	For 012 Feed	Plus 7° Clearance
3/64"	20°12'	2°20'	9°20'
1/16"	22°24	1°45	8°45'
5/64"	20°13'	1°24'	8°24'
3/32"	19°21'	1°10'	8°10'
7/64"	21°25	1°0'	8°0'
1/8"	18°59	0°52'	7°52'
9/64"	21°46'	0°47'	7°47'
5/32"	24°34'	0°42'	7°42'
11/64"	24°8'	0°39	7°39'
3/16"	22°56'	0°35'	7°35'

Fig. 10 Point Study of $^{3}/_{8}$-In. Drill Sharpened on Machine *E*

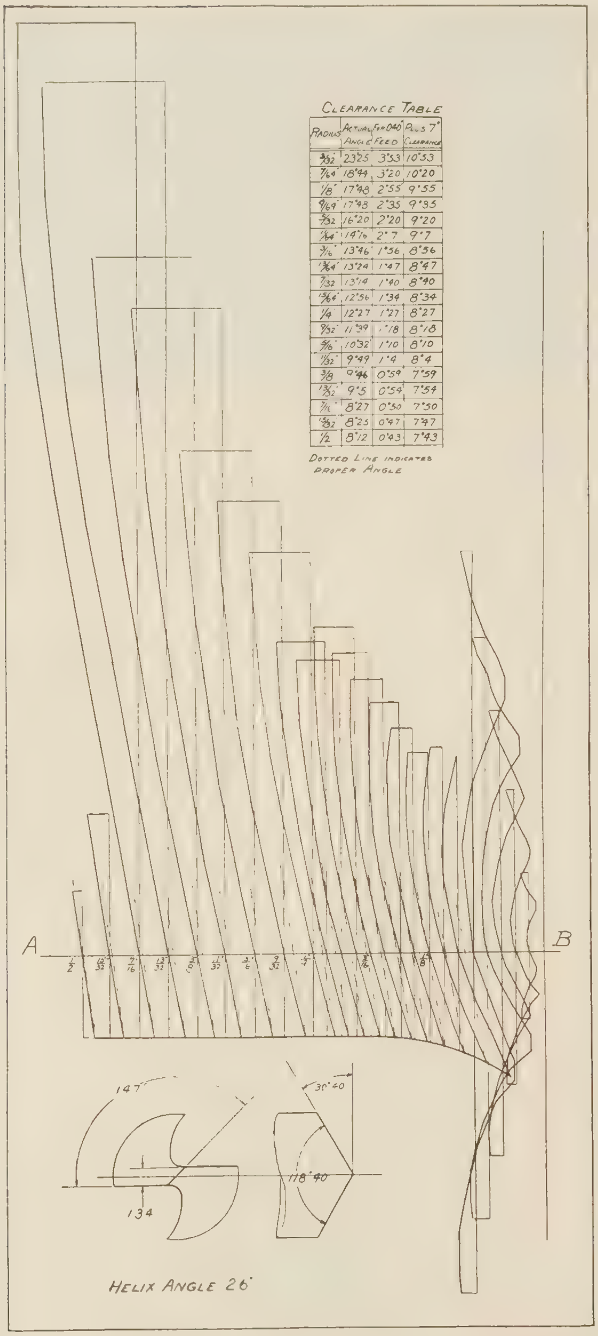


FIG. 11 POINT STUDY OF 1-IN. DRILL SHARPENED ON MACHINE *A*

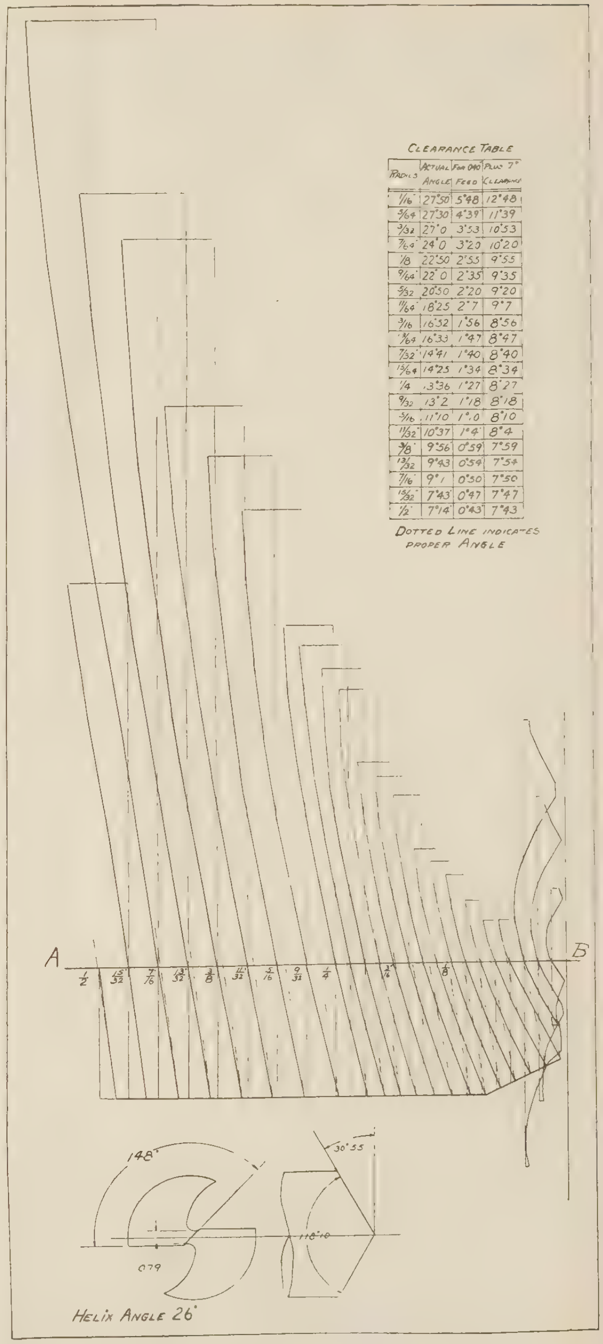


FIG. 12 POINT STUDY OF 1-IN. DRILL WITH POINT THINNED, SHARPENED ON MACHINE *A*

order that the drill may cut at the feed designated. The drills sharpened on machine *A* have a comparatively straight cutting edge, while those sharpened on machines *D* and *E* have an extreme angle of clearance. Of course, the angle of clearance that is very far back of the cutting edge is unimportant; however, the excessive angle shown in Fig. 10 seems unnecessary. If the angle is not great enough, the drill will rub back of the cutting edge and will be unable to free itself. If the angle is too great, the cutting edge is much too weak.

It will be noticed that the point angle on these drills varies considerably from that which is usually considered as proper, namely, 118 deg included angle. Even drills ground in the same machine, although the sizes vary, do not necessarily have the same angle. The same peculiarities are found, as are shown, in the other sizes. In this group, attention is called to drills ground on machine *B*, and the peculiar shape of the point will be noted. There are two angles on the point. In other words, the corners are beveled or rounded off to insure longer cutting life of the drill. This gives the peculiar cutting-edge form shown in Fig. 8.

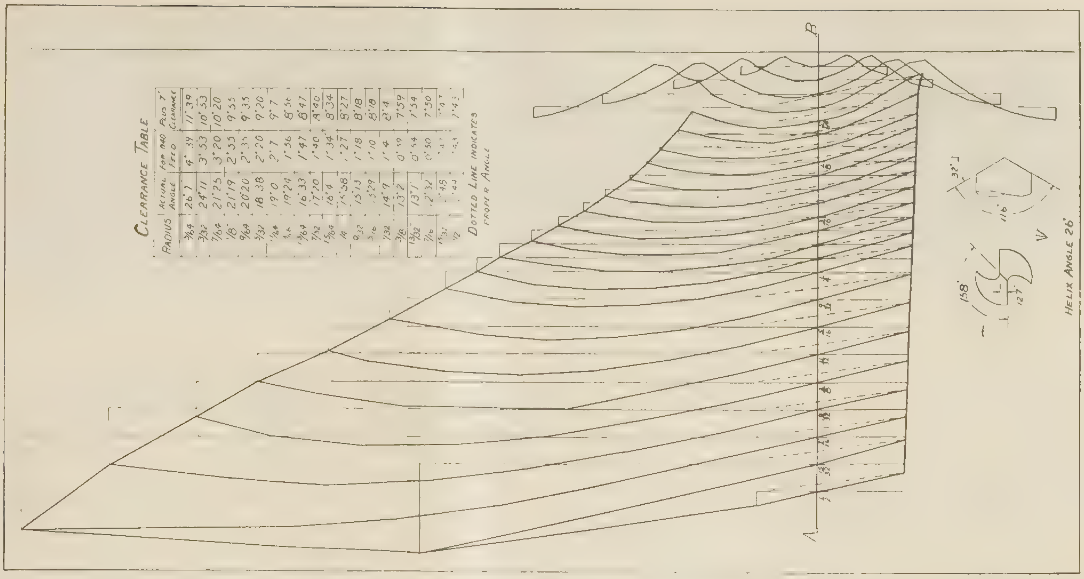


FIG. 15 POINT STUDY OF 1-IN. DRILL SHARPENED ON MACHINE *C*

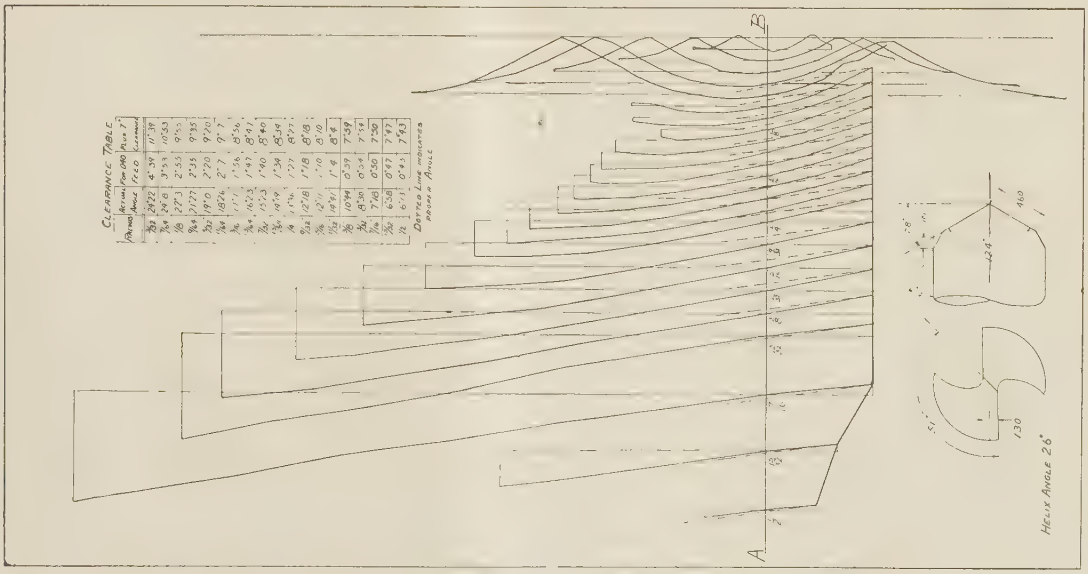


FIG. 14 POINT STUDY OF 1-IN. DRILL WITH CORNERS BEVELED, SHARPENED ON MACHINE *B*

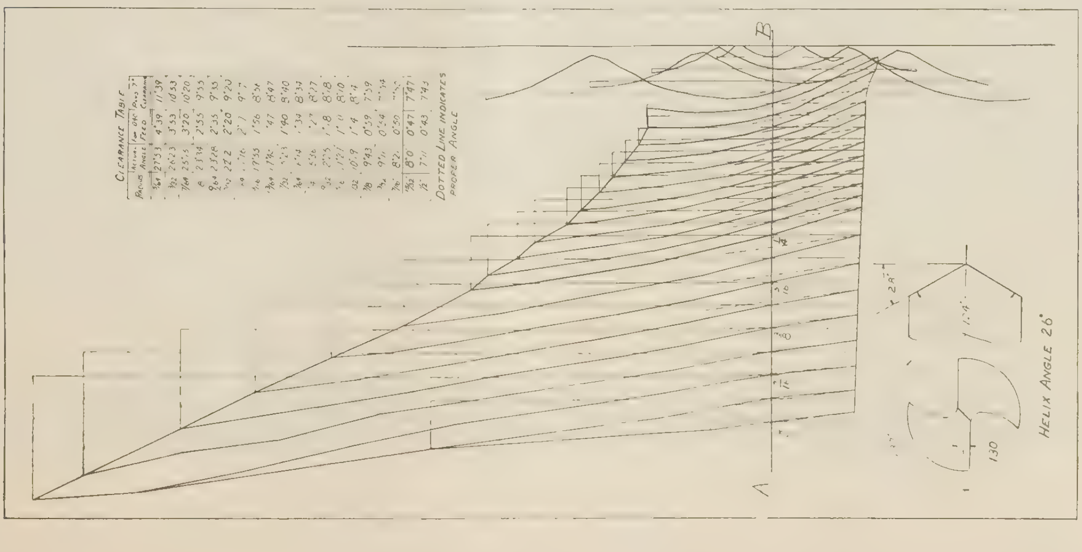


FIG. 13 POINT STUDY OF 1-IN. DRILL SHARPENED ON MACHINE *B*

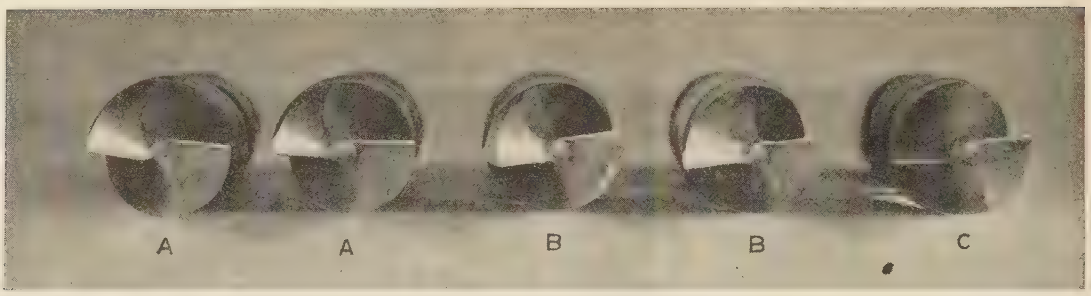


Fig. 16 Condition of Points of 1-In. Drills After the Tests

The action of rounding the corner on a twist drill is not new. This was discussed by Benedict and Lukens in their investigation of drills in 1917.[2]

Fig. 10 showing the drill sharpened on machine E gives the same peculiar curve as obtained in the other drills sharpened on this same machine. It shows an unusual amount of clearance, and yet the curve swings back to the right, which means that all of the clearance is not available as may appear from the first look at the figure.

Figs. 11, 12, 13, 14, and 15 show 1-in. drills ground on machines A, B, and C, respectively. Fig. 11 shows a drill that comes as close to the theoretical—if it may be called that—of any that

[2] "An Investigation of Twist Drills," Part I, by B. W. Benedict and W. Penn Lukens, Engineering Experiment Station Bulletin No. 103, November 26, 1917, pp. 80–82. University of Illinois, Urbana, Ill.

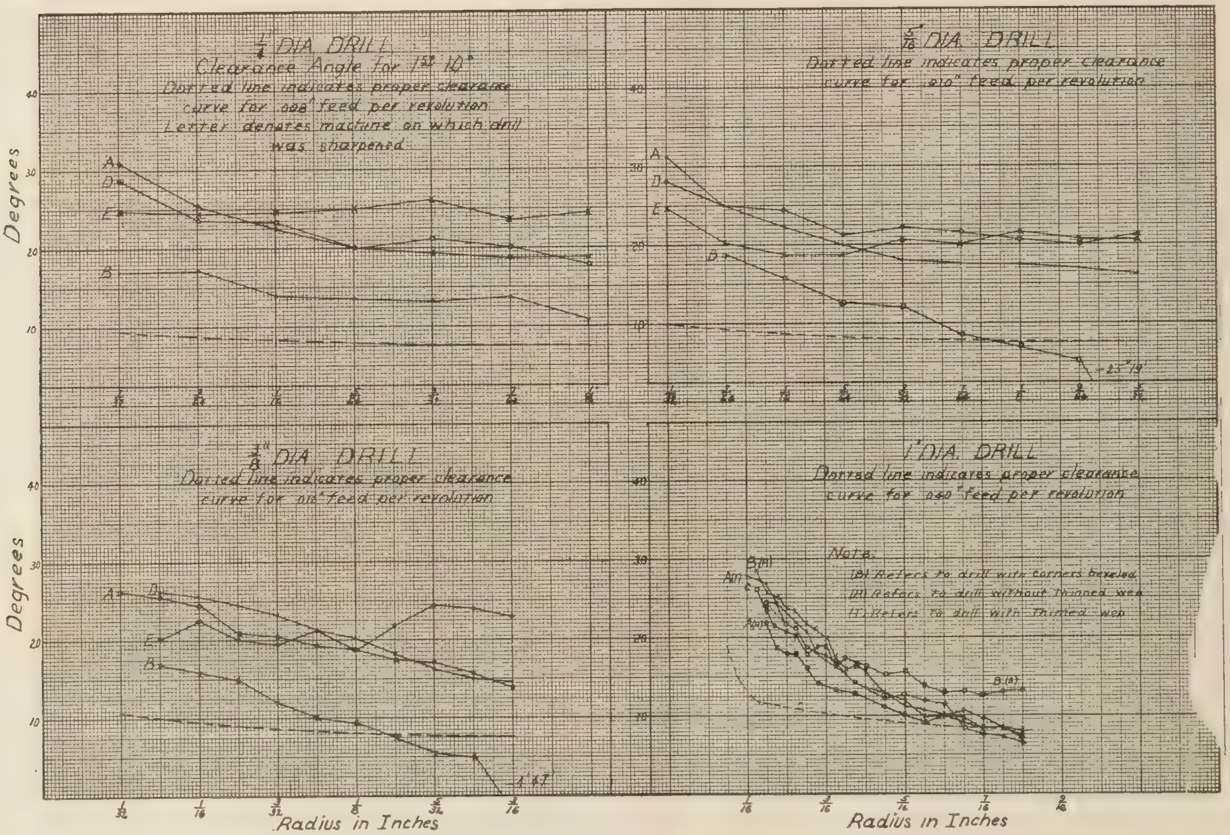


Fig. 17 (Top Left) Comparison of Summarized Clearance Curves for 1/4-In. Drills

(Letters on curves denote the machine on which the drills were sharpened. The dashed line indicates the proper clearance curve for a feed of 0.008 in. per revolution. Clearance angle for the first 10 deg.)

Fig. 18 (Top Right) Comparison of Summarized Clearance Curves for 5/16-In. Drills

(Dashed line indicates proper clearance curve for a feed of 0.01 in. per revolution. Letters on curves indicate the machine on which the drills were sharpened.)

Fig. 19 (Bottom Left) Comparison of Summarized Clearance Curves for 3/8-In. Drills

(Dashed line indicates proper clearance curve for a feed of 0.012 in. per revolution. Letters on curves indicate the machine on which the drills were sharpened.)

Fig. 20 (Bottom Right) Comparison of Summarized Clearance Curves for 1-In. Drills

(Dashed line indicates proper clearance curve for a feed of 0.04 in. per revolution. Letters on curves indicate the various drills shown in Fig. 16. The letters in parentheses indicate condition of grinding as follows: (B) refers to drill with corners beveled, (R) refers to drill without thinned web, and (C) refers to drill with thinned web.)

have as yet been discussed. At the $^1/_2$-in. radius, it will be found that the actual angle of clearance is 8 deg 12 min while the so-called "correct angle" would appear as 7 deg 43 min. However, near the center, much more clearance appears than is actually needed. If these curves are followed, particularly the $^3/_{32}$-, $^7/_{64}$-, and $^1/_8$-in. curves, it will be found that they have a tendency to bend to the right, which means that there is likely to be an interference there, or a rubbing action of that part of the drill against the material being cut.

Fig. 12 shows a 1-in. drill ground on the same machine as the one illustrated in Fig. 11, but in this case, with the point thinned. This shows that the trouble already mentioned as appearing in Fig. 11 is eliminated, because the curve of the lip-clearance surface is not as long.

All the drills discussed so far, the author believes, have been sharpened with the drill being held with its axis in a horizontal plane. This means that any changes, due to wear, on the face of the wheel will be likely to be reproduced in the lip-clearance angle, and the cutting edge will not necessarily be a straight line. It has been found in some cases that the cutting edge deviated as much as 0.040 in. from a straight line.

Fig. 13 shows a 1-in. drill as ground on machine *B* with a standard point. Fig. 14 shows a drill ground on the same machine, but with the corners beveled. This gives a peculiar cutting edge, as was noticed in the smaller sized drills.

In Fig. 15 is shown a development of the drill ground against the face of the wheel, but in this case, the drill is held with its axis in a vertical plane. It will be noticed that the curves of clearance come nearer to approaching straight lines than do most of those heretofore shown. However, trouble occurs toward the center of the drill, as has been mentioned before, by the drill rubbing back of the cutting edge.

The condition of the 1-in. drills after testing is shown in Fig. 16. The difference between the two drills *A* will be noted. The one on the left has the point thinned. Less rubbing action will be noted at the chisel edge than in the other drill marked *A*. With drill *C* considerable rubbing action has taken place as is shown by the ball of metal at the chisel edge. The same holds true with the drills marked *B*.

In Figs. 17, 18, 19, and 20, the curves of the drills as ground on various machines are summarized and compared. The degrees of clearance are plotted against radii. It will be noticed that the curves are extremely peculiar, and show little similarity.

The dashed lines represent what would be the correct clearance curve with a feed that has been assumed for a given diameter and an additional allowance of 7 deg clearance. As shown in Fig. 17, $^3/_8$-in. drills show an even greater variation, but the curves for 1-in. drills in Fig. 20 lie reasonably close together.

Figs. 21, 22, 23, and 24 show curves wherein the drills are classified, according to the machine, on which they are ground. The curves for drills ground on machine *A* shown in Fig. 21 lie reasonably close together except the curve for the $^1/_8$-in. drill.

Fig. 22, for drills ground on machine *B* show curves for the two 1-in. drills that lie quite close together, but the smaller drills

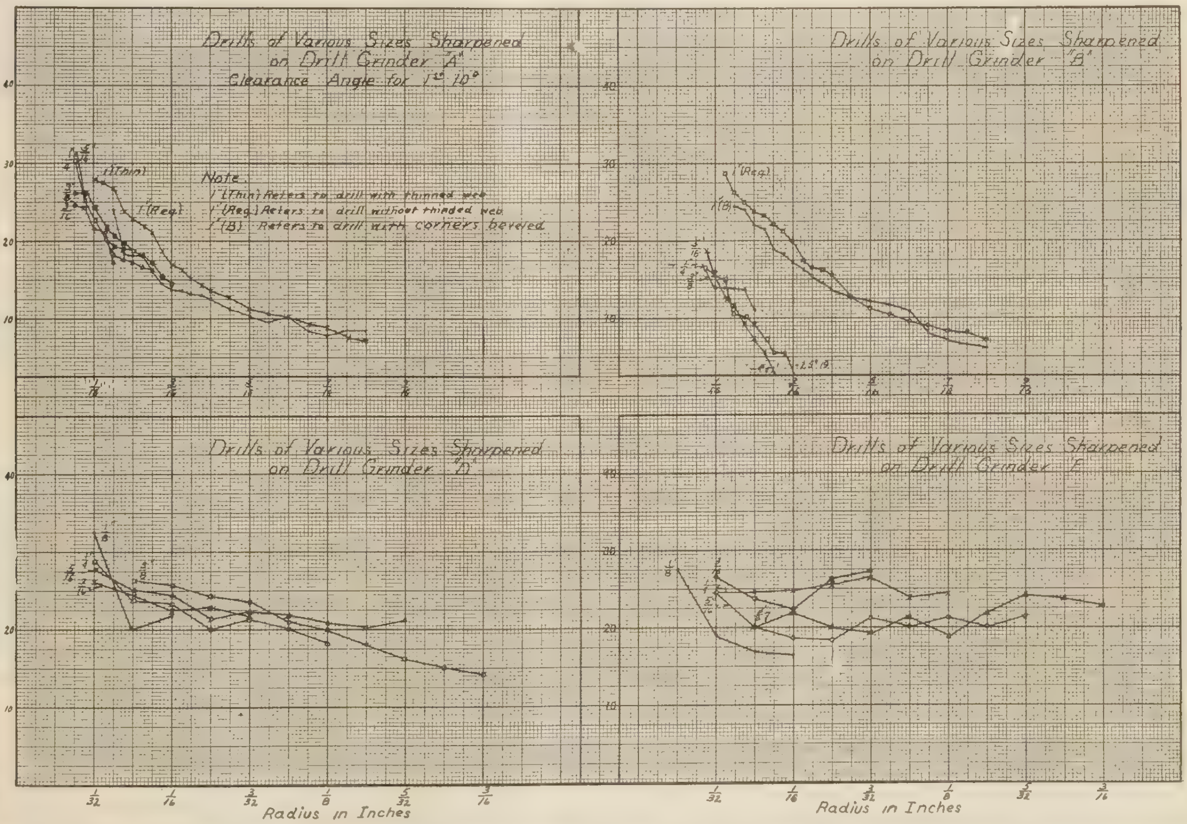


Fig. 21 (Top Left) Clearance Angles of Drills Sharpened on Machine *A*
(Clearance angle for the first 10 deg.)

Fig. 22 (Top Right) Clearance Angles of Drills Sharpened on Machine *B*

Fig. 23 (Bottom Left) Clearance Angles of Drills Sharpened on Machine *D*

Fig. 24 (Bottom Right) Clearance Angles of Drills Sharpened on Machine *E*

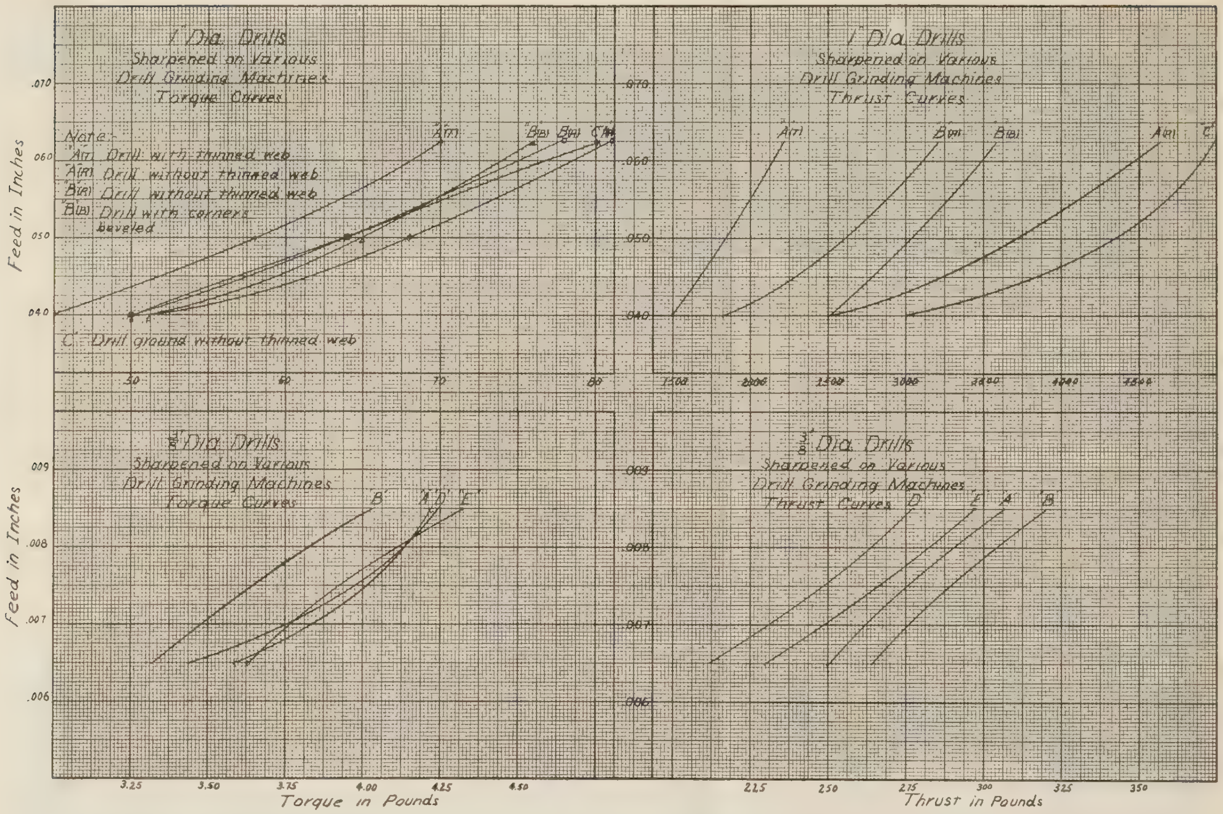


Fig. 25 (Top Left) Torque Developed With 1-In. Drills
(Letters on curves indicate the following: $A(T)$ drill with thinned web; $A(R)$ drill without thinned web, $B(R)$ drill without thinned web, $B(B)$ drill with corners beveled, and C drill ground with corners beveled. The letters before the parentheses refer to the drills shown in Fig. 16.)

Fig. 27 (Top Right) Thrust on 1-In. Drills
(Letters on curves have same reference as given in Fig. 25.)

Fig. 26 (Bottom Left) Torque Developed With $^3/_8$-In. Drills
(Letters on curves indicate machine on which drills were sharpened.)

Fig. 28 (Bottom Right) Thrust on $^3/_8$-In. Drills
(Letters on curves indicate machine on which drills were sharpened.)

seem to vary considerably. With machine *D*, curves for which are shown in Fig. 23, this variation is increased much more. In this case, the drills are all ground on the same size machine.

The curves for a group of drills ground on machine *E* are shown in Fig. 24. The fact that these curves do not lie together, shows that the method of holding the drill or method of locating the drill on the holder is such that the operator can make a mistake and not clamp all drills the same. This condition apparently holds true for drills ground on machine *D*.

The curves for drills ground on machine *B*, which are shown in Fig. 22 run reasonably close together, for the small and also large drills, and yet, a wide variation between the two groups, while the curves for drills ground on machine *A*, shown in Fig. 21, lie to a great extent together even though in this case, the small drills are ground on one size of machine, and the large drills ground on another.

After studying the clearance angles of these various drills, they were tested in machines equipped with dynamometers. The 1-in. diameter drills were tested on the drilling machine used by Benedict and Hershey.[3] The small drills were tested on a high-speed drilling machine and dynamometer developed by the author. Torque and thrust were taken by springs and the deflection of these springs registered on dial indicators. The springs were calibrated in place on the machine against known loads and calibration curves established. These drills were tested in commercial iron that had been cast in the university foundry. The cutting speed for the drills was approximately 60 fpm. The blocks were annealed and the Rockwell hardness found to average 77.5 B on the large blocks and 76 B scale on the small blocks. The chemical composition of these blocks was 2.18 silicon, 0.081 sulphur, 0.57 phosphorus, 0.52 manganese, 3.50 carbon.

In Figs. 25, 26, 27, and 28 are shown torque and thrust curves for drills tested. These curves show that no set of drills as sharpened on any particular machine may be considered superior to another, in so far as torque and thrust are concerned except in the case of the 1-in. drill with the thinned point. Here a slight difference will be noticed in the torque curve, but a considerable difference appears in the thrust curve as may be expected.

Examination of the holes drilled showed that all drills cut about the same as to size and finish except those drills with the beveled corners. These drills produced holes that were nearer to the drill size and had a better finish than holes produced with drills having standard points. This fact is not considered as showing a superiority of grinding machine *B*, because the same might have resulted if drills had been beveled after sharpening in the other machines.

The beveling of the corners did show a decided factor in endurance tests of $^3/_8$-in. drills. These tests were run using test

[3] "An Investigation of Twist Drills," Part II, by B. W. Benedict and A. E. Hershey, Engineering Experiment Station Bulletin No. 159, November 16, 1926. University of Illinois, Urbana, Ill.

TABLE 2 TABULATED DATA OF TORQUE AND THRUST OF DRILLS GROUND ON VARIOUS MACHINES

Drill-grinding machines	Feed in. per rev	Torque, lb	Thrust lb
1-in. drills			
A (st'd)	0.0399	50	2420
A (thin)	0.0399	45	1400
B (st'd)	0.0399	50	1920
B (bev)	0.0399	50	1965
C	0.0399	51	3030
A (st'd)	0.0499	68	2650
A (thin)	0.0499	58	1833
B (st'd)	0.0499	64	2620
B (bev)	0.0499	65	3000
C	0.0499	64	4330
A (st'd)	0.0623	83	4550
A (thin)	0.0623	70	2290
B (st'd)	0.0623	78	3300
B (bev)	0.0623	76	3460
C	0.0623	80	4900
5/16-in. drills			
A	0.0065	2.26	188
B	0.0065	2.58	221
D	0.0065	2.23	193
E	0.0065	2.59	232
A	0.0074	2.50	213
B	0.0074	2.88	247
D	0.0074	2.63	223
E	0.0074	2.85	263
A	0.0085	2.70	244
B	0.0085	3.24	287
D	0.0085	2.87	249
E	0.0085	3.22	309
3/16-in. drills			
A	0.0047	0.61	119
D	0.0047	0.60	114
E	0.0047	0.55	114
A	0.0057	0.65	138
D	0.0057	0.68	118
E	0.0057	0.69	121
A	0.0065	0.75	145
D	0.0065	0.85	136
E	0.0065	0.82	139
3/8-in. drills			
A	0.0065	3.52	244
B	0.0065	3.50	263
D	0.0065	3.41	208
E	0.0065	3.55	225
A	0.0074	3.92	267
B	0.0074	3.59	286
D	0.0074	3.88	243
E	0.0074	3.86	260
A	0.0085	4.22	307
B	0.0085	4.11	330
D	0.0085	4.25	272
E	0.0085	4.32	297
1/4-in. drills			
A	0.0065	1.37	169
B	0.0065	1.54	158
D	0.0065	1.43	153
E	0.0065	1.51	176
A	0.0074	1.60	184
B	0.0074	1.83	184
D	0.0074	1.65	174
E	0.0074	1.69	191
A	0.0085	1.86	212
B	0.0085	2.12	210
D	0.0085	1.99	210
E	0.0085	2.12	225
1/8-in. drills			
A	0.0041	0.10	89
D	0.0041	0.12	73
E	0.0041	0.10	59
A	0.0047	0.12	108
D	0.0047	0.23	83
E	0.0047	0.14	68
A	0.0057	0.14	137
D	0.0057	0.23	83
E	0.0057	0.14	68

blocks of S.A.E. 6150 steel. This steel had been normalized and had a Rockwell hardness of 92 B. A sulphurized mineral oil was used as a coolant. A surface speed of 166 fpm and a feed of 0.0085 in. per revolution were used. All drills ground with the standard point failed early in the test while the drills with beveled corners did not fail at all and appeared in very good condition at the end of the test.

The results of this test were as follows: A drill ground on machine *A* drilled 5 holes, 1 in. deep; a drill ground on machine *B* drilled 11 holes, 1 in. deep and was still in good condition at end of test; a drill ground on machine *D* drilled 2 holes, 1 in. deep; and a drill ground on machine *E* drilled 4 holes, 1 in. deep. The only reason that drill *B* was not run to destruction was that the test material was exhausted.

A summary of the torque and thrust data is shown in Table 2. An analysis of this table shows, more completely, the results that have been plotted in Figs. 25, 26, 27, and 28. A study of the figures given in Table 2 confirms the statement previously made that no grinding machine is superior to another in all cases. The only real difference occurs in the drill with the thinned point.

The small drills were copper-plated on the point, the better to detect any rubbing that might occur. On the 5/16-in. and 1/4-in. drills, that were sharpened on machine *B*, considerable rubbing was detected on the beveled corners.

It is hoped that this paper will suggest a future study of this subject at which time drills sharpened on various machines should be tested in different materials. Complete endurance tests should also be run for it seems possible after this study of the lip-clearance angle that one grinder may have points that make it superior for sharpening drills for different materials or other conditions of use. The author intends to continue this study in the near future.

In closing, it might be well to state that in this study, there is no intention to criticize the design of the various drill-sharpening machines used, but rather to criticize the operators of these machines. Too often, the operator does not use proper caution when setting the drill preparatory to sharpening it. It does appear, however, that one might well raise the question of making these machines as near foolproof as possible so that the operator cannot go wrong, and must necessarily reproduce time after time the point that the machine manufacturers intended should be produced on their machines.

Acknowledgments

The results presented in this paper were obtained in connection with an investigation conducted by the Engineering Experiment Station, of which M. L. Enger, dean of the college of engineering, is the director, in the department of mechanical engineering of which O. A. Leutwiler, professor of mechanical engineering design is head. These results will ultimately comprise part of a bulletin of the Engineering Experiment Station. Acknowledgment is also due the Latrobe Company of Latrobe, Pennsylvania, for furnishing the small drills; also, to the various manufacturers of drill-grinding machines for sharpening the drills used in these tests.

The Economic Characteristics of Typical Business Enterprises

By WALTER RAUTENSTRAUCH,[1] NEW YORK, N. Y.

This paper presents the results of analyses of the relationship between incomes and expenses of a wide range of types of business, over a period of years during which incomes and expenses expanded and contracted greatly. The data upon which these analyses were based were taken principally from the published financial statements found in Moody's Financial Manual, Poor's Financial Manual, Crandall's Corporate Analyst, and various government publications.

The results of these analyses indicate that business enterprises may be compared with each other in ways heretofore impossible and as a result of such comparisons their relative economic worths may be judged.

IT HAS been suggested[2] that the total expenses of every business enterprise tend to vary with income according to the general equation

$$\text{Total expense} = a + bx$$

where a = constant total expense, bx = variable total expense, x = income.

This paper presents the results of analyses of the relations between incomes and expenses of a wide range of types of business, over a period of years during which incomes and expenses expanded and contracted greatly. The technique devised to determine the trend of expense with income was as follows:

A 45-deg line was drawn on a sheet of cross-section paper and equal scales were used for both horizontal and vertical measurements. The incomes for each year were laid off along the base to scale, as shown in Fig. 1 at oa, oa', and oa'', and verticals drawn through the points a, a', a'' terminating at the 45-deg line at b, b', and b''. Thus $ab = oa$ = income. The corresponding total expenses were laid off to scale along the appropriate verticals as shown at c, c', and c''. A trend line drawn through the points c, c', and c'' by inspection, determined the relation between expense and income.

[1] Professor of Industrial Engineering, Columbia University. Mem. A.S.M.E. Mr. Rautenstrauch was graduated from the University of Missouri in 1902 with the degree of bachelor of science. In 1902–1903 he was instructor at the University of Maine where he received the M.S. degree, and from 1904 to 1906 he was assistant professor at Cornell University. He received the degree of LL.D. in 1932 from the University of Missouri. He has occupied his present position at Columbia University since 1906, and is also consulting engineer to various manufacturing industries. He is a member of the National Research Council and numerous societies and is the author of a number of books; he has contributed many articles to the technical press and is a recognized authority on technology.

[2] "The Economic Characteristics of the Manufacturing Industries," by Walter Rautenstrauch, Mechanical Engineering, vol. 54, November, 1932, p. 759.

Contributed by the Management Division for presentation at the Semi-Annual meeting of The American Society of Mechanical Engineers, to be held in Detroit, Michigan, May 17 to 21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 W. 39th Street, New York, N. Y. and will be accepted until June 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

These studies show that the relationship between expense and income for many businesses follows closely the general law suggested in the earlier paper.[2]

Those few companies, for which the relation between income and expense is found to be somewhat erratic at times, seem to have either adjusted their selling prices drastically or have failed to follow a consistent policy of operations during the times when these erratic behaviors appear. The data upon which these analyses are based were taken principally from the published financial statements found in Moody's Financial Manual, Poor's Financial Manual, Crandall's Corporate Analyst, and various government publications.

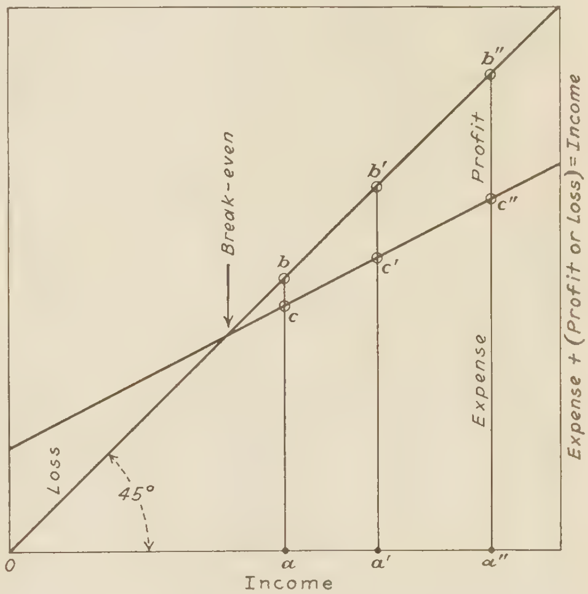


Fig. 1

The results of these analyses also indicate that business enterprises may be compared with each other in ways heretofore impossible and as a result of such comparisons their relative economic worths may be judged. Such comparisons are made and discussed in the following pages.

A The Automobile Industry

1 *The General Motors Corporation*

The financial reports of this company from 1909 to 1934 compiled in Poor's Financial Manual were analyzed and the relations between annual incomes and total expenses for the period of 25 years were plotted as shown in Fig. 2. There appear to be three distinct groups of trends of the total expenses. From 1909 to 1919 when the company was in its formative period, the relation between income and total expense shows no specific trend, due perhaps to the fact that new developments and additions brought about varying conditions from year to year. The company expanded very rapidly from 1920 to 1928 during

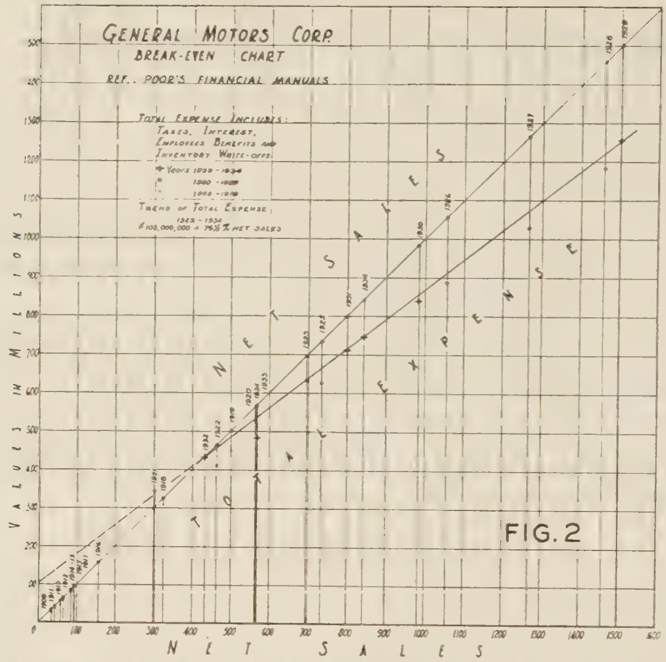


FIG. 2

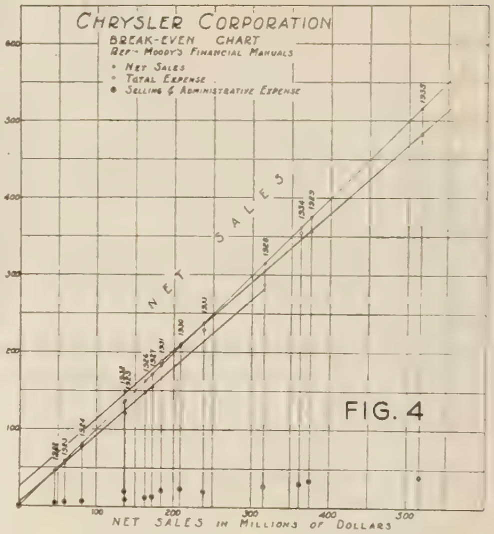


FIG. 4

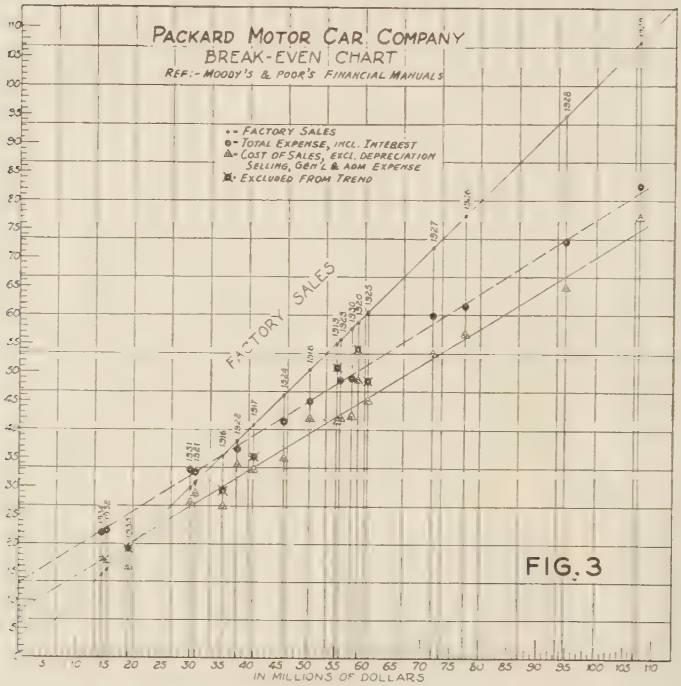


FIG. 3

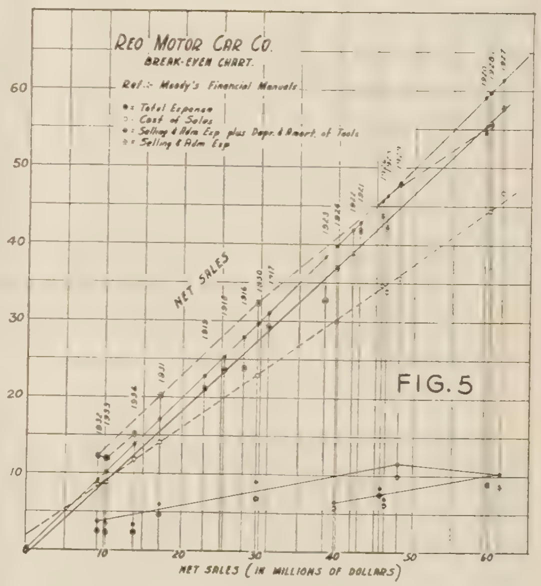


FIG. 5

which time it began to show a more definite trend of total expense to income. In 1929 the company experienced its maximum income (approximately $1,500,000,000) and then in common with all industries its sales declined to less than 30 per cent of the maximum in 1932. Since that date income from sales has increased each year and in 1934 was over $840,000,000. During the period from 1929 to 1935 the trend between income and total expense is very definite except for the year 1932 when it appears that the total expenses reported were exceptionally low. It is interesting to note that not only did the total expenses for the years 1930, 1931, and 1932 recede along definite trends, but that they are tending to follow the same trends upward as the income from sales increases. The present trend of total expense seems to follow the expense line shown in Fig. 2.

The equation of total expense is

$$\text{Total annual expense} = \$105{,}000{,}000 + (76.5 \text{ per cent of net sales})$$

Since this chart was constructed and the total-expense line and its equation were determined, the General Motors Corporation has issued its financial report for the year 1935. This report shows annual net sales of $1,155,641,510 and total expenses of

$988,210,920. The equation of annual total expense gives the result $989,065,755 which is less than $^1/_{10}$ of 1 per cent from the actual expense reported. More recently the company reported the results of operations for the first quarter of 1936 to be net sales of $341,306,065 and total expenses of $288,841,891. The equation of annual total expense for this company reduced to a quarterly basis is

Quarterly total expense = $26,250,000 + (76.5 per cent of net sales)

Applying this equation to the net sales reported for the quarter, the result is $287,349,000 or approximately $^1/_2$ of 1 per cent of the total expense reported for the quarter. Apparently this company is being operated with surprisingly close control of total expense in relation to income and therefore the total expenses and hence the profit from operations can be closely approximated for any annual or quarterly sales income by the use of the foregoing equations.

The equation of annual profit for this company is obviously found, from the equation of annual expense, to be

Annual profit = (23.5 per cent of net sales) — $105,000,000

The quarterly profit is accordingly

Quarterly profit = (23.5 per cent of net sales) — $26,250,000

The annual sales at which the company will break even may be found from the equation of annual profit by finding the net sales for which the annual profit is equal to zero. Thus the annual break-even point of this company is

Annual break-even point = $447,000,000

In summary, the economic characteristics of the General Motors Corporation are, for the period 1929 to 1935:

Fixed expense point	(annual) =	$105,000,000
	(quarter) =	26,250,000
Variable expense factor	=	0.765
Total expenses	(annual) =	$105,000,000 + (76.5 per cent of sales)
	(quarter) =	26,250,000 + (76.5 per cent of sales)
Profits	(annual) =	(23.5 per cent of sales) — $105,000,000
	(quarter) =	(23.5 per cent of sales) — $ 26,250,000
Break-even point	(annual) =	$447,000,000

2 Packard Motor Car Company

The financial reports of this company as published in Moody's and Poor's Financial Manuals for the years 1916 to 1934 were analyzed and the results charted as shown in Fig. 3.

The line of total annual expenses in relation to annual income was drawn to define the predominant trend. Only six years of the total of 19 plotted, fall far outside of the trend; two of which are war years (1916–1917) and one (1920) was a year during which many companies had comparatively high labor costs. However there are probably better explanations of these variations which could be found if one had access to the details of the accounts. From 1918 to 1934 a period of 17 years, with the exception of 1933, the trend of annual total expenses is found to be

Annual total expenses = $13,000,000 + (63.2 per cent of factory sales)

Quarterly total expenses = $3,250,000 + (63.2 per cent of factory sales)

The other general economic characteristics of this company are found to be:

Annual fixed expense point	= $13,000,000
Variable expense factor	= 0.632
Annual profit	= (36.8 per cent of factory sales) — $13,000,000
Annual break-even point	= $35,300,000

3 Chrysler Corporation

The break-even chart of this company is shown in Fig. 4. From 1922 to 1928 the total-expense line is the lower of the two shown in the chart, while from 1929 to 1935 the total annual expenses follow the trend shown in the upper line. The fixed charges of the company were increased materially after 1928 so that the break-even point was raised from approximately $40,000,000 to $227,000,000. This increase is due in part to an increase in administrative and selling expenses in greater proportion to sales income after 1927, as shown near the bottom of the chart. A shift of the trend line of total expense in relation to sales income may also be caused by a lowering of prices. Since this chart shows always the *relation* between income and expense, a shift in the trend of expense may be brought about by either a change in expenses or a change in selling prices, or both. Note for example, the incomes and expenses for 1929 and 1934 in which the expenses in the two years are approximately equal. If 1934 prices had been higher by approximately $3^1/_2$ per cent then both expenses and incomes for 1929 and 1934 would have coincided, that is, the expense point for 1934 would have shifted horizontally to the right while the income point would have traveled up the 45-deg incline to coincide with 1929.

We have not sufficient information on the details of prices and expenses of this company to state why the expense line shifted for the period 1929 to 1935, above that for the period 1922 to 1928. The interesting point is that there are these persistent straight-line relationships between income and expense for a span of years and over a wide range of sales. If the period for 1929 to 1935 is an indication of present trends, then this company appears to have the following economic characteristics

Annual fixed expense point	= $25,000,000
Variable expense factor	= 0.89
Equation of annual total expense	= $25,000,000 + (89 per cent of net sales)
Equation of annual profit	= (0.11 of net sales) — $25,000,000
Break-even point (annual)	= $227,270,000

After the above analysis was made and during the preparation of this text, the New York Times reported July 25, 1936, that the sales and net profits of the Chrysler Corporation for the 6-months period ending June 30, 1936, were $358,634,899 and $29,473,736, respectively. The total expenses for this period are therefore $329,161,163. The equation of average total expense for a six-months period is

Avg 6-months total expense = $12,500,000 + (89 per cent of net sales)

According to this equation the probable total expense for this period should be $331,685,000, which is $2,520,000 or about 0.76 per cent greater than the actual expense. Departures from this amount are to be expected because of differences in interest and other charges from year to year as the following comparative statements quoted from the report in the New York Times show

Income Accounts Compared

(Consolidated income account for the six months ended on June 30th)

	June 30, 1936	June 30, 1935
Sales	$358,634,899	$295,569,895
Cost of sales	292,224,109	251,187,187
Gross profit	66,410,790	44,382,708
Interest and miscellaneous income	381,884	685,963
Total income	66,792,674	45,068,671
Administrative, engineering, selling, advertising, service, and general expenses	25,656,703	20,657,928
Interest paid and accrued, and (in 1935) premium of $1,507,525 on debentures called, and (in 1933) additions to reserves	82,766	2,223,336
	25,739,469	22,881,264

Profit before provision for federal, state, and foreign income, excess profits and undistributed profits taxes...........................	41,053,204	22,187,406
Provision for federal, state, and foreign income, excess profits, and undistributed profits taxes...........	11,579,467	3,528,097
Net profit....................	$29,473,737	$18,659,309
Depreciation and amortization charged to cost of sales and expenses in amounts of............	$7,583,724	$13,656,520

4 Reo Motor Car Company

This company presents an interesting case somewhat different from the conditions encountered in the above companies. The break-even chart of this company is shown in Fig. 5. The general trend of total expense from 1916 to 1928 follows the full line drawn immediately below the 45-deg line of income. The expense points are somewhat scattered and four of them (for the years 1916, 1923, 1921, and 1929) fall wide of the trend. Next below the trend line of total expense we find the broken line of "cost of sales" (cost of manufacturing the goods sold). This trend of cost of sales is very uniform for the period from 1924 to 1934. Comparing the trend line of total expense with the trend line of cost of sales from 1924 to 1928 we find that as sales income increased, the administrative and selling expense increased at a greater rate, that is, the spread between the two lines increased as sales income increased. When sales declined in 1929 the cost of sales dropped consistently with income, but the administrative and selling expense in relation to income did not. In fact, the spread between total expense and cost of sales increased between 1927 and 1929 as the chart clearly shows.

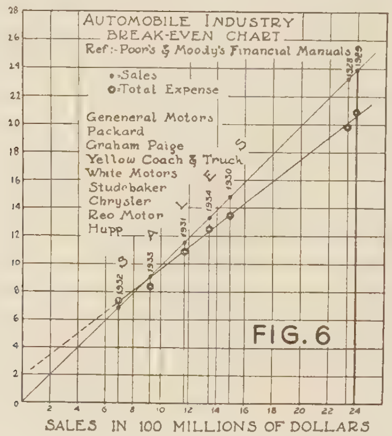


FIG. 6

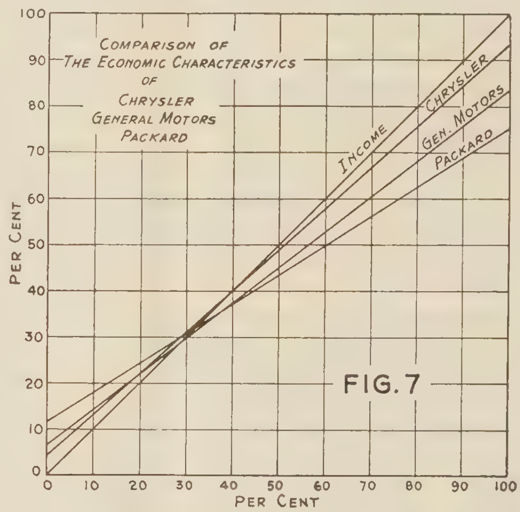


FIG. 7

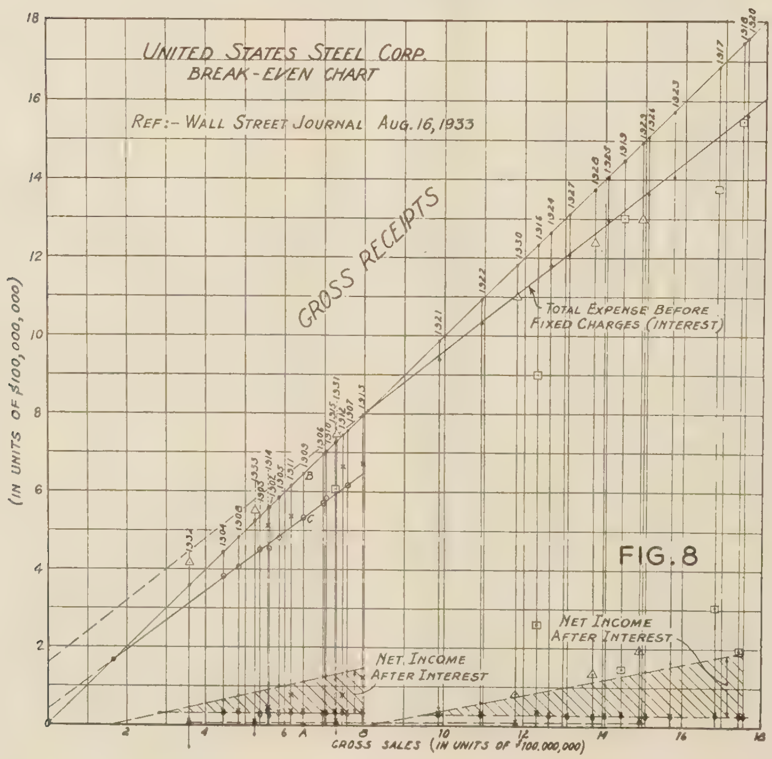


FIG. 8

As sales declined still further in 1930, the company ran into a loss. Further declines in sales as shown for 1931 and 1932, while accompanied by a drastic reduction of administrative and selling expenses, showed substantial losses. The cost of sales trend, however, followed the same line which it had in the earlier years. As sales increased in 1933 and 1934, still further reductions in the general overhead were brought about and losses were reduced, but the cost of sales returned along the same trend line which it had in earlier years. This company apparently did not have control of its total expenses particularly the general overhead, which the other companies previously considered appear to have had and while its cost-of-sales line showed a uniform relationship to sales income over a wide range of sales and for a considerable span of years, its administrative and sales expenses and hence the total expenses showed erratic behavior in relation to income.

5 Consolidated Break-Even Chart of Several Companies

The annual sales and annual total expenses of several automobile manufacturing companies were compiled and the results used to construct the break-even chart shown in Fig. 6. The companies were General Motors, Packard, Graham-Paige, Yellow Coach and Truck, White Motors, Studebaker, Chrysler, Reo, and Hupp. These represent a typical group, outside of the Ford Motor Co. This chart shows the following economic characteristics for the group for the period 1928 to 1934

Annual fixed expense point	=	$190,000,000
Variable cost factor	=	0.78
Equation of annual total expense	=	$190,000.000 + (78 per cent of sales)
Equation of annual profit	=	(22 per cent of sales) — $190,000,000
Break-even point	=	$862,000,000 annual sales

6 Comparison of Economic Characteristics of Several Companies

The break-even chart shows, among other things, the relation of total expense to income over a range of sales. The charts of the several automobile companies just examined show that they each differ from one another in both fixed and variable expenses in relation to income. Since, however, they also differ in productive capacity it is not possible to make a direct comparison of their break-even charts. In order that this may be done, each chart must be set up in terms of per cent of productive capacity or on other appropriate bases. The records do not show what the productive capacity of each company is and therefore this must be approximated by assuming that the maximum capacity is represented by the maximum sales.

Three companies will be compared on this basis: General Motors, Chrysler, and Packard. The maximum sales in each case were

General Motors	$1,504,400,000	1929
Packard	107,500,000	1929
Chrysler	517,000,000	1935

The ratios of the fixed costs to maximum sales and the variable cost factors are

	Fixed cost max sales per cent	Variable cost factor per cent
General Motors	7	76.5
Packard	12.1	63.2
Chrysler	4.8	89

The comparative break-even charts shown in Fig. 7 were constructed from these data. This graphic analysis shows that when each company is run at maximum capacity, the Chrysler Corporation has a profit of 6.2 cents for every dollar of income, the General Motors Corporation has 16.5 cents and Packard has 24.7 cents or approximately 4 times that of Chrysler and $1^1/_2$ times that of General Motors. It is interesting to note that the Packard Company has the highest fixed costs in proportion to maximum income and the lowest variable costs, while the Chrysler Corp. which has the lowest ratio of fixed costs to maximum sales has the highest variable costs.

The total assets of these companies at the time of their maximum sales were

General Motors	$1,324,889,000 in 1929
Packard	78,789,000 in 1929
Chrysler	151,133,000 in 1935

Accordingly, in these years General Motors showed a profit of approximately 19 cents per dollar of total assets, Packard showed 33.7 cents and Chrysler 21.2 cents.

B Steel

The economic characteristics of companies operating in this industry are illustrated by the records of operation of the largest company in the industry, The United States Steel Corp., and one of the smaller units, The Granite City Steel Co.

1 United States Steel Corporation

The records of gross receipts and total expenses before interest charges of this company from its formation in 1902 to 1933 are given in Table 1.

TABLE 1 UNITED STATES STEEL CORPORATION

Data from Crandall's Corporation Reports, Oct. 6, 1934
The Wall Street Journal, Aug. 16, 1933
(in $1000 units)

Year	Gross receipts	Total expense	Net earnings	Interest charges	Net income after interest charges
1902	560,510	453,685	106,825	22,034	84,791
1903	536,573	451,612	84,961	25,637	59,324
1904	444,405	382,570	61,835	30,091	31,744
1905	585,332	481,939	103,389	29,767	73,622
1906	696,757	570,649	126,108	29,401	96,707
1907	757,015	617,282	139,733	29,353	110,380
1908	482,308	405,701	76,607	31,264	45,343
1909	646,382	534,923	111,499	31,504	79,955
1910	703,961	583,395	128,566	30,630	89,936
1911	615,149	537,528	77,621	31,145	46,476
1912	745,506	665,632	79,874	32,569	47,305
1913	796,894	672,875	124,019	32,518	91,501
1914	858,415	513,772	44,643	32,322	12,321
1915	726,684	607,110	119,574	31,783	87,791
1916	1,231,474	900,524	260,950	31,026	299,924
1917	1,683,963	1,377,608	306,355	30,126	276,229
1918	1,744,312	1,548,228	196,084	29,822	166,262
1919	1,448,558	1,300,886	147,672	29,211	118,461
1920	1,755,477	1,563,754	191,723	28,514	163,209
1921	986,750	939,720	47,030	27,745	19,285
1922	1,092,698	1,032,958	59,740	27,492	32,248
1923	1,571,414	1,407,097	164,317	27,072	137,245
1924	1,263,711	1,179,905	83,806	26,343	57,463
1925	1,406,505	1,296,977	109,528	26,006	83,522
1926	1,508,076	1,365,942	142,134	25,515	116,619
1927	1,310,393	1,209,903	100,490	24,665	75,825
1928	1,374,443	1,239,184	135,259	23,788	111,471
1929	1,493,505	1,298,228	195,277	14,945	180,332
1930	1,180,935	1,099,455	81,480	5,640	75,840
1931	729,377	748,885	—19,508	5,470	—24,978
1932	357,202	416,875	—59,673	5,313	—64,986
1933	524,969	550,695	—25,726	5,165	—30,891

These data are plotted in Fig. 8. This chart shows four distinct eras in the expense history of the company. From its foundation in 1902 to the year 1910, the expenses followed a very regular trend in relation to gross receipts. This trend was

Avg annual total expense = $40,000,000 + (76 per cent of gross receipts)

The corresponding equation of net earnings was

Avg annual net earnings = (24 per cent of gross receipts) — $40,000,000

The break-even point before interest charges of the business during that era was approximately $166,000,000. The chart shows that the break-even point after interest charges was about $300,000,000. The company at that time had a heavy bonded indebtedness. The next era was for the four years of 1911 to 1914, the trend line for which is not drawn. Then followed the war

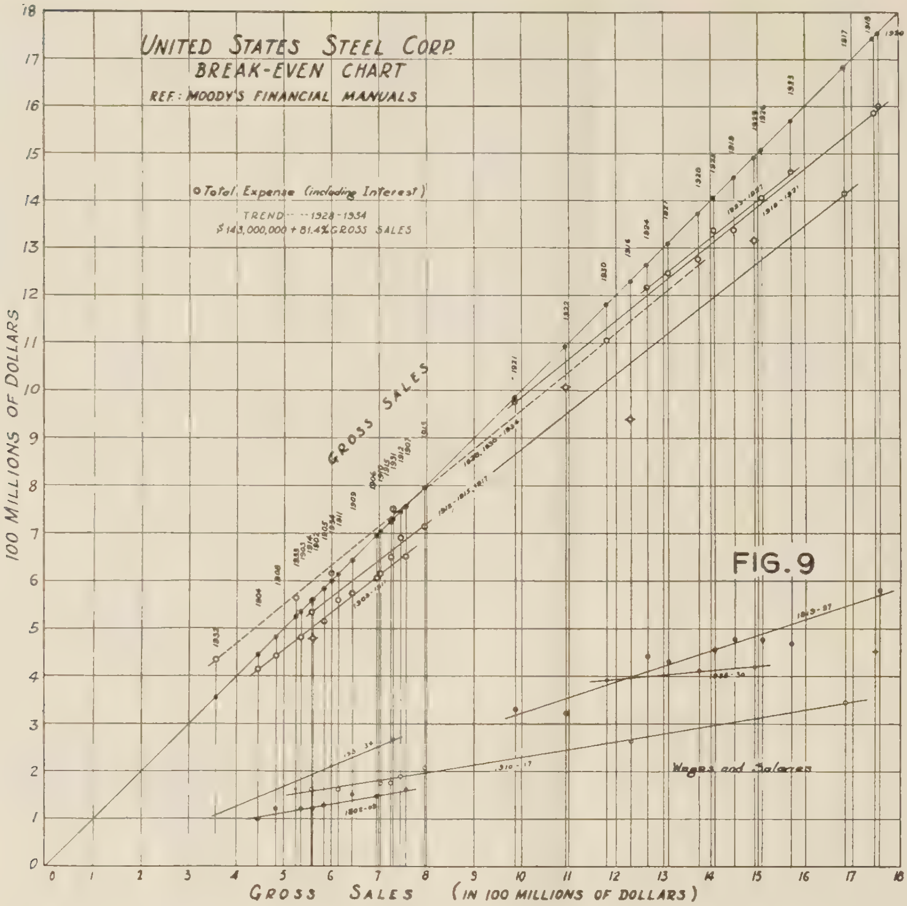


FIG. 9

years of 1915 to 1917 during which the company experienced the greatest earnings in its history in the years 1916 and 1917. During 1918 its total expense in relation to gross receipts became greater and initiated the trend of the next era. The fourth era included the largest output in the company's history when in 1920 its gross receipts were slightly over $1^3/_4$ billion dollars. For a period of ten years from 1918 to 1927 during which sales fluctuated widely, the trend of expense was

Avg annual total expense = $158,000,000 + (80 per cent of gross receipts)

The equation of profit for this era was

Avg annual net earnings = (20 per cent of gross receipts) — $158,000,000

The company now needed to have annual gross receipts of $790,000,000 to break even before interest charges. A comparison between the actual net earnings and those computed by the above equations is given in Table 2. It is interesting at this time to note that the conditions under which the company was operating during this era were such that it broke even at a point where it formerly, in this first era, made its maximum profit and that to make the same profit it formerly made at $800,000,000, gross receipts, it had to have annual gross receipts of approximately $1,550,000,000 or nearly twice as much. In view of the fact that its invested capital was also much greater, this change in the earnings characteristics of the company is very significant.

In 1928 and 1929 the spread between total expenses and gross receipts was increased, but in 1930 and 1931 it approached the trend of the post-war era. As sales continued to decline to the lowest in the history of the company in 1932 ($357,000,000) and then continued to rise in 1933 the expenses in relation to gross receipts followed below the earlier trend.

When the total expenses including interest charges are plotted against gross sales we find a series of trends as shown in Fig. 9. It will be seen from this chart that the addition of interest charges

TABLE 2 UNITED STATES STEEL CORPORATION NET-EARNINGS TRENDS

Symbol	Era	Period	Years	Equation
	First	1902–1910	9	$0.24x$ — $40,000,000
	Fourth	1918–1927	10	$0.20x$ — 158,000,000

Years	By equation	Actual	Difference	
First era				
1902	$ 94,522,400	$106,825,000	+12,302,600	
1903	88,777,520	84,961,000	− 3,816,520	
1904	66,657,200	61,835,000	− 4,822,200	
1905	100,479,680	103,389,000	+ 2,909,320	
1906	127,221,680	126,108,000	− 1,113,680	
1907	141,683,600	139,733,000	− 1,950,600	
1908	75,753,920	76,607,000	+ 853,080	
1909	115,131,680	111,499,000	− 3,632,680	
1910	128,950,640	128,566,000	− 384,640	
Total	939,178,320	939,523,000	+ 344,680	
Average	104,351,146	104,391,444	+ 38,299	+0.04%
Fourth era				
1918	190,862,400	196,084,000	+ 6,021,600	
1919	131,711,600	147,672,000	+15,960,400	
1920	193,095,400	191,723,000	− 1,372,400	
1921	39,350,000	47,030,000	+ 7,680,000	
1922	60,539,600	59,740,000	− 799,600	
1923	156,282,800	164,317,000	+ 8,034,200	
1924	94,742,200	83,806,000	−10,936,200	
1925	123,301,000	109,528,000	−13,773,000	
1926	143,615,200	142,134,000	− 1,481,200	
1927	104,078,600	100,490,000	− 3,588,600	
Total	1,237,578,400	1,242,524,000	+ 494,560	
Average	123,757,840	124,252,400	+ 49,456	+0.4%

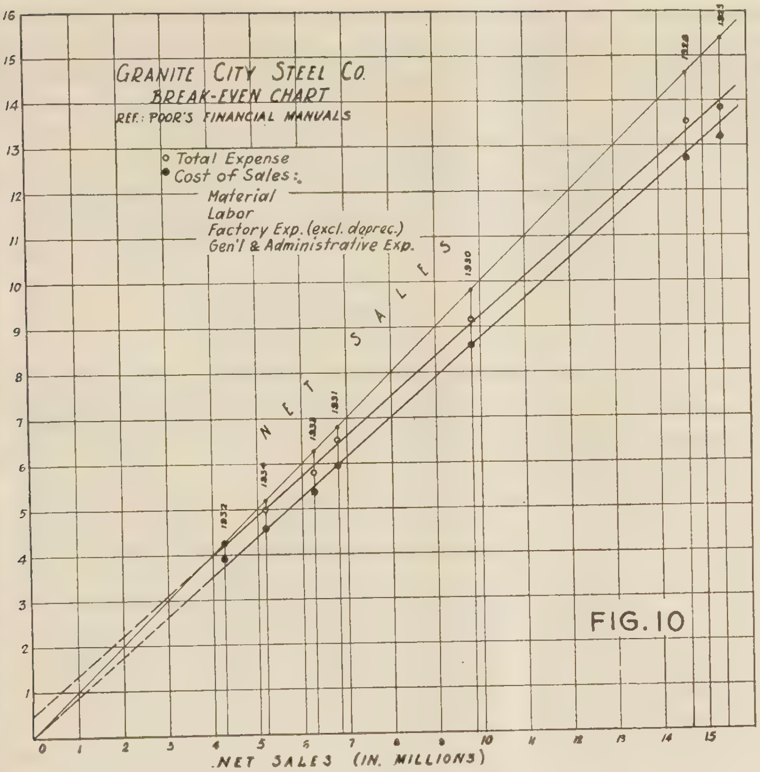


FIG. 10

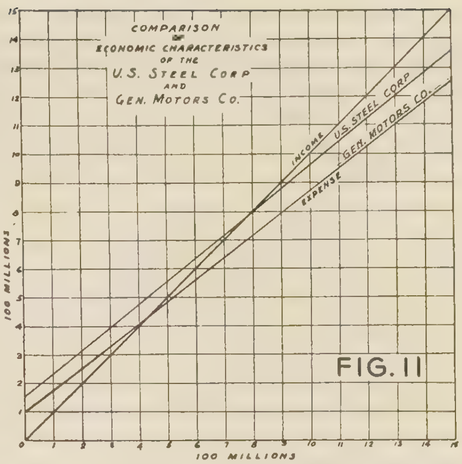


FIG. 11

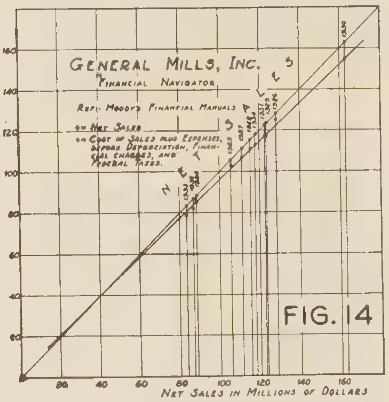


FIG. 14

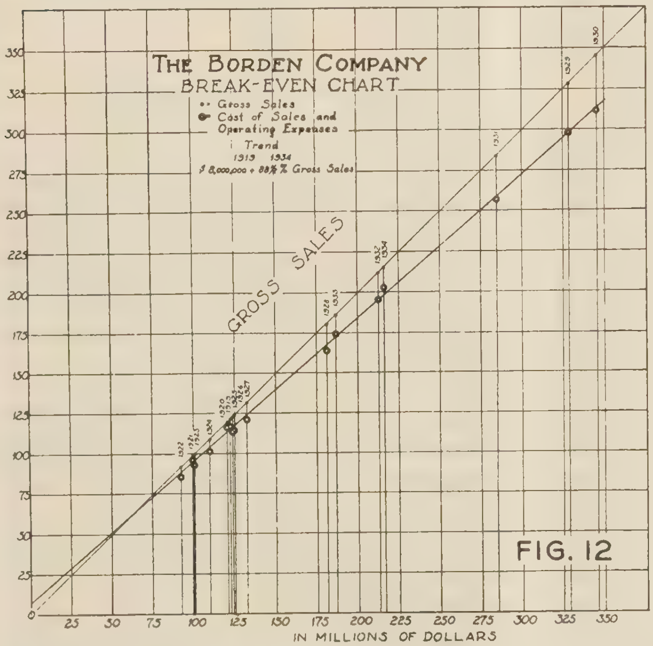


FIG. 12

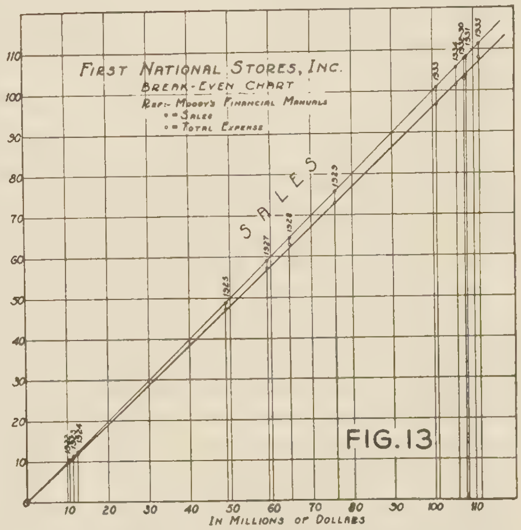


FIG. 13

establishes more distinctive trends. For example, from 1923 to 1927, the total expenses including interest charges had a trend above the 1918 to 1921 showing, with a distinct drop for the period 1928 to 1934 in which 1929 is not included. If the company should continue its operations along this trend it appears that it should have

Avg annual net income = (18.6 per cent of gross sales)—$143,000,000

This chart also shows how wages and salaries have varied throughout the years. Comparing the trend in wages and salaries for the period 1902 to 1909 with that for the period 1921 to 1934, it will be observed that wages and salaries account for a large portion of the difference in trends of total expenses for the periods 1903 to 1911 and 1928 to 1934.

2 The Granite City Steel Co.

This company in terms of maximum output is less than 1 per

cent the size of the United States Steel Corp. Its record of income and expense since 1929 is shown in Fig. 10. This chart shows both cost of sales and total expense in relation to net sales. The company has shown a profit all during the depression period and its trend of expense has been very consistent. This trend is

Avg annual total expense = \$500,000 + (87.5 per cent of net sales)

3 Comparison of U. S. Steel and General Motors Corporations

These two companies are approximately the same size as measured in terms of maximum sales. The maximum gross receipts of the United States Steel Corp. in 1920 were $1^3/_4$ billion dollars. The net sales of the General Motors Corp. in 1929 were $1^1/_2$ billion dollars. The relative income-expense trends of the two companies are compared in Fig. 11. This chart shows the superior position of the General Motors Corp. to the United States Steel Corp. in terms of earnings per dollar of income, and in the range of sales over which earnings are made. The chart does not show what is even more significant, and that is, that the United States Steel Corp. has approximately one billion dollars more capital than General Motors and hence the earnings in terms of invested capital are even more favorable to the General Motors Corp.

C Food Products

1 The Borden Company

The principal business of this company is the collection, processing and distribution of milk in the city of New York. It also produces and distributes ice cream and handles some dairy products. From 1919, when its business was slightly less than 125 million dollars annual sales, it grew to enjoy a volume of sales of slightly less than 350 million dollars in 1930. Since then its sales dropped to about 185 millions in 1933 from whence they rose to about 230 million dollars in 1935. During all these years, while the annual business increased and decreased substantially, its cost of sales and operating expenses followed a consistent general trend in relation to income, as shown in Fig. 12. The company shows a very low break-even point, approximately 20 per cent of maximum income, although this is before administrative expenses and financial charges which data were not available to us.

2 First National Stores

This company conducts a large chain of grocery stores and its business has grown from a little more than 10 million dollars sales in 1922 to over 110 million dollars in 1935. Throughout this entire period of time, its total expenses have been maintained at a fixed percentage of sales income, approximately 96.25 per cent as shown in Fig. 13. This means that for every dollar of sales, the company makes a profit of $3^3/_4$ cents. This company in common with many other chain groceries, seems to have a fixed cost point at zero. This does not mean that the company has no constant total expenses in its budget, but rather that as the company increased its operations, it controlled the increase of its rents and other fixed cost items in proportion to the increase in income.

3 General Mills, Inc.

This company owns and operates flour mills and distributes flour over a wide territory. The reports of its operations show costs of sales before depreciation, financial charges, and federal taxes for the period from 1925 to 1933 to have followed a straight-line trend in relation to net sales as shown in Fig. 14. Only in 1926 was there an appreciable increase in these costs while in 1932 and 1933 they were somewhat less than the general trend. The company has a very narrow spread between these expenses and the income and when the other costs are accounted for it probably has a very high break-even point.

4 The Great Atlantic & Pacific Tea Co.

This company operates one of the largest chains of grocery stores in the world. Its total expenses in relation to income, for a long period of years and over a wide range of sales, as shown in Fig. 15, have been uniformly 97.3 per cent. For every dollar of income therefore, the company averages a profit of 2.7 cents. This record has been maintained from 1924 when its sales were slightly more than 300 million dollars, to 1931 when sales were over 1 billion, 60 million dollars. When sales declined in 1932, 1933, and 1934, its total expenses continued to follow the same trend.

D An Office Building

1 Equitable Office Building Corporation

The business of owning and operating an office building for profit is a wholly different affair from the production and merchandising of manufactured goods or the distribution of groceries, yet it also shows very definite trends of expense in relation to income.

The Equitable Office Building Corp. owns and operates one of the largest office buildings in the financial district of New York City. In this type of business enterprise the constant total costs are very high and the variable total costs are comparatively low. The record of incomes and expenses for this business for the years 1924 to 1935 are plotted as shown in Fig. 16 from which it is found that the trend of total expense in relation to income is

Annual total expense = \$2,300,000 + (26 per cent of income)

and the equation of profit is

Avg annual profit = (74 per cent of income)—\$2,300,000

while the break-even point is

Annual break-even point = \$3,100,000

E Electrical Manufacturers

1 The General Electric Company

This company is one of the largest manufacturers of electrical machinery and allied equipment in the world. In 1910 its annual sales were approximately 70 million dollars and in 1929 they were over 400 million dollars, or nearly six times as great. Since 1929, annual sales receded to about 135 million in 1933, from whence they rose to 233 million for the year closing June 30, 1936. Throughout this whole period of years a wide range of annual sales, the company has shown a most remarkable control of total expenses in relation to income. This is clearly indicated in Fig. 17 which shows the relation of total expenses to net sales of this company from 1910 to 1932. There appear to be four general eras on this chart for two of which, the first and third eras, are given the equations of profit trend. The first era is from 1910 to 1917 during which the trend in total expense was

Annual total expenses = \$3,000,000 + (86.33 per cent of net sales)

The second era was from 1918 to 1921 for which no trend is drawn. The third era was from 1922 to 1927 during which the trend of total expenses was

Annual total expenses = \$9,000,000 + (86.7 per cent of net sales)

The fourth era from 1929 to date shows that during the decline in sales from 1929 to 1933, expenses in relation to sales were slightly greater than in the third era while sales were rising, but as sales began to rise again there seems to be a tendency to follow the expense trend of the third era. It seems to be a fair probability that with increasing business this company should follow the trend of total expenses which it had from 1922 to 1929. In this event its break-even point would be approximately

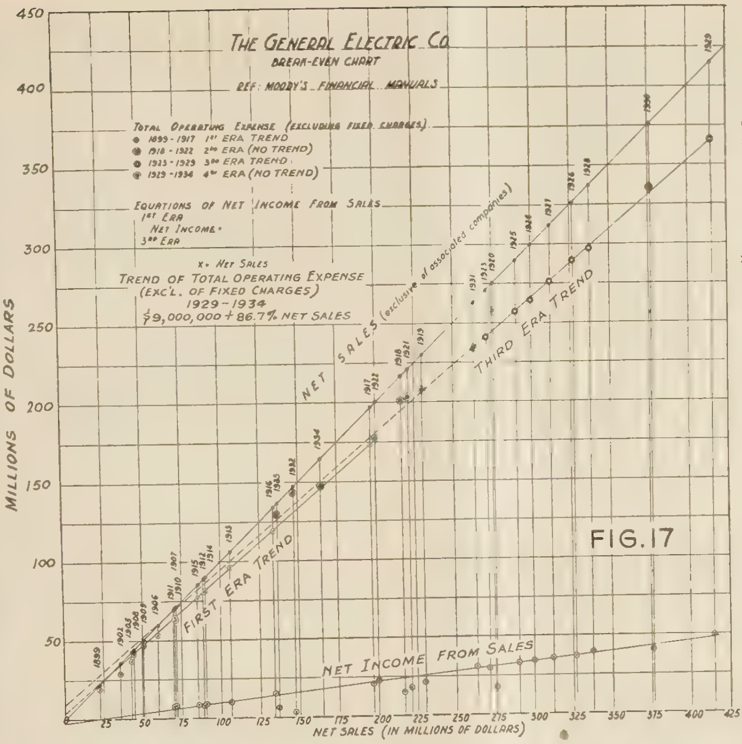


FIG. 17

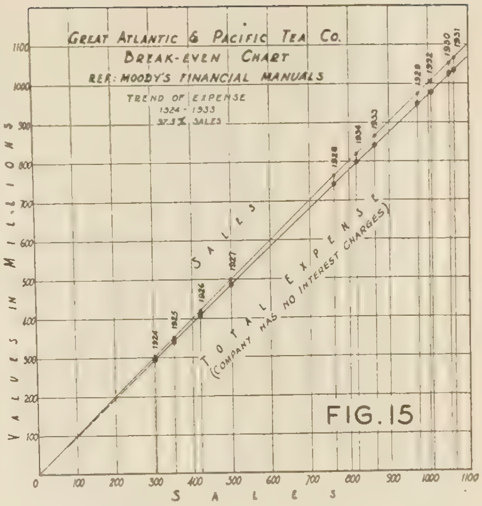


FIG. 15

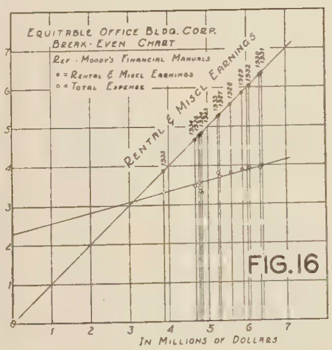


FIG. 16

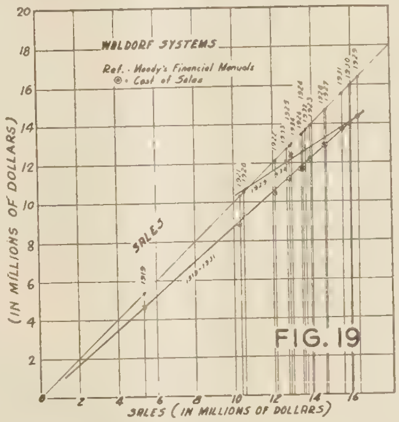


FIG. 19

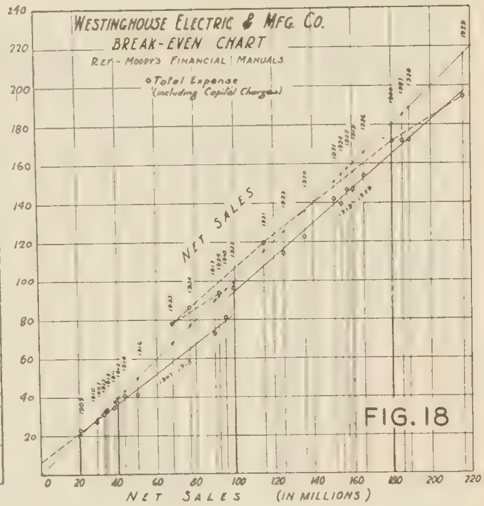


FIG. 18

$67,600,000 annual sales or about 15 per cent of maximum sales of 1929.

In support of this estimate of probable expense trend, we present the following comparisons of actual total expenses from sales for the years closing June 30, 1935 and 1936, and the computed expenses

	1935	1936
12 months billing	$178,360,497	$233,460,547
Costs and expenses	165,440,573	210,160,307
Computed from equation of trend	163,630,000	211,410,000
Difference	1,810,573	1,249,693
Per cent difference	1.1	0.6

The total average costs and expenses for the two years is $187,800,000 and that computed for the average sales for the two years is $187,520,000 or a difference of 0.17 per cent.

Since the General Electric Co. derives a large income from other sources than from the sale of the products it manufactures, the total net income of the company is frequently greater than the net income from sales alone. For example, in the year closing June 30, 1936, the company reported net income from sales amounting to $23,300,240 and other income, less charges of $9,594,427, bringing its net income up to $32,894,667. Only the net income from sales is compared with the total expense in the above analysis.

2 Westinghouse Electric and Manufacturing Company

This well-known company manufactures and distributes about the same kind of products as the General Electric Company. An analysis of its incomes and expenses as reported in Moody's Financial Manuals from 1907 to 1934, and plotted in Fig. 18 shows three distinct phases in its earnings history. From 1907 to 1918 its annual sales range from over 20 million dollars in 1909 to about 96 million in 1918. During this entire period, its annual total expenses in relation to annual net sales followed the general trend

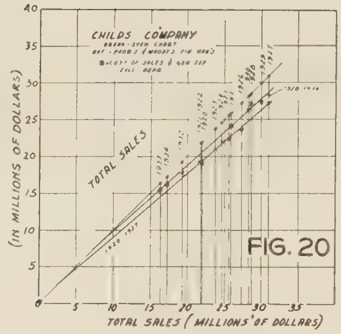


FIG. 20

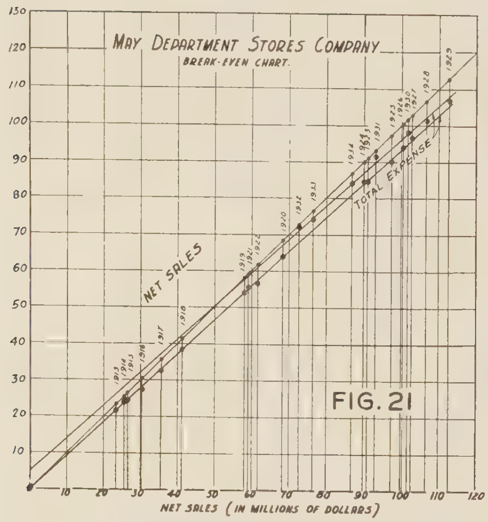


FIG. 21

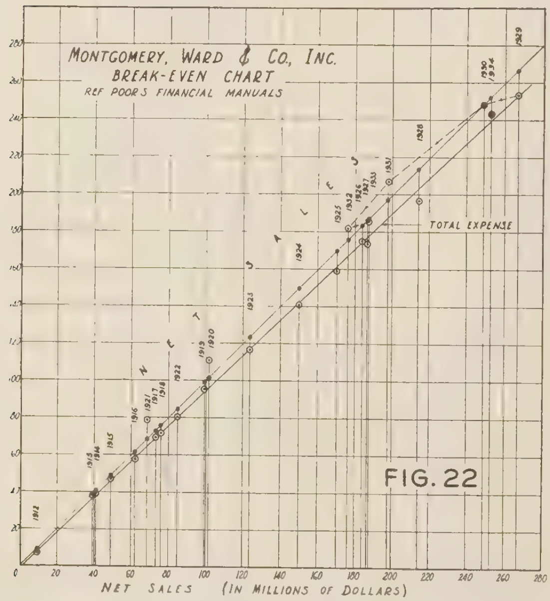


FIG. 22

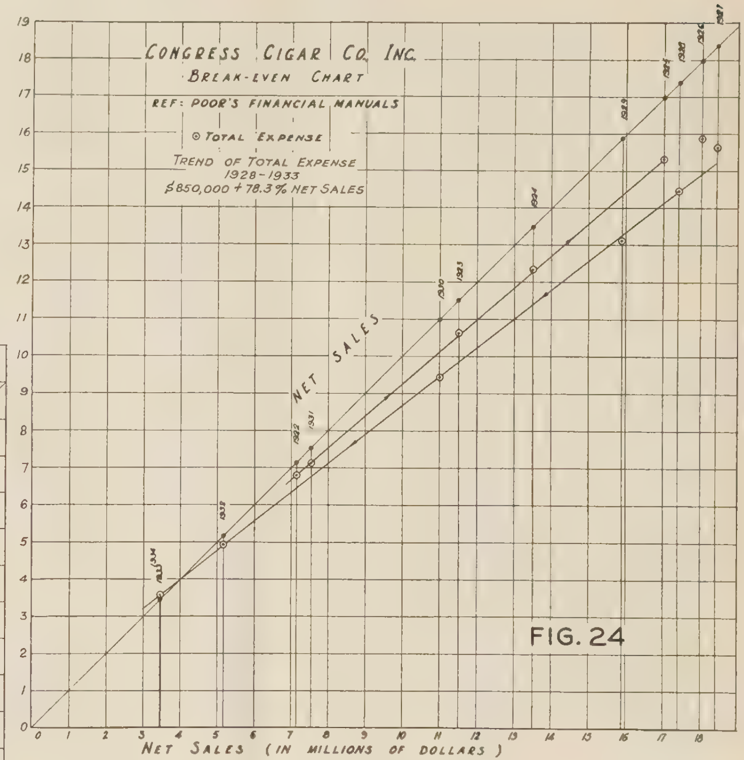


FIG. 24

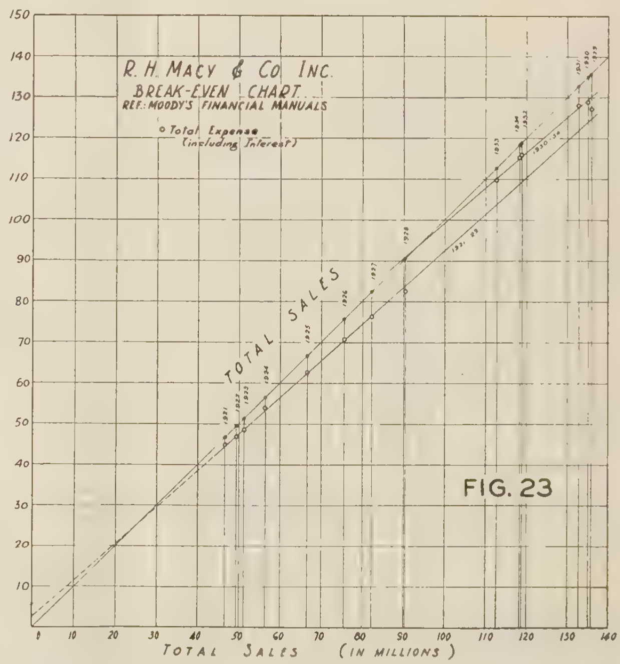


FIG. 23

Annual total expense = \$6,000,000 + (78 per cent of net sales)

and it broke even at annual net sales of \$27,000,000. From 1919 to 1929 its business increased materially and ranged from slightly less than 100 million dollars annual net sales in 1922 to about 216 million in 1929. During this period it altered the relation between the annual total expenses to annual net sales, for which the trend was

Annual total expense = \$8,000,000 + (87 per cent of net sales)

Its break-even point was also raised to approximately \$61,000,000. It is interesting to observe that whereas its equation of profits from 1907 to 1918 was

Avg annual profits = (20 per cent of net sales)—$6,000,000

after its expansion, its profits from 1919 to 1929 followed the general trend

Avg annual profits = (13 per cent of net sales)—$8,000,000

Accordingly, should the company have had, for example, annual net sales of 100 million dollars during any year between 1907 and 1918, the probabilities are that it would have had a profit of approximately (20 per cent of $100,000,000)—$6,000,000 or $14,000,000. After its expansion, however, if it were to have an annual profit of $14,000,000 it would have had to have annual sales of

$14,000,000 = (13 per cent of net sales) — $8,000,000, or approximately $170,000,000

Thus the company after its sales expanded, found that its margin of profit had narrowed and that it had to do about 70 per cent more business than its previous maximum capacity to make the same annual profit as before.

F Restaurants

1 Waldorf System, Inc.

This company operates a chain of restaurants. In 1919 its annual sales were over $5^1/_4$ million dollars and 10 years later it did an annual business of over 16 million dollars, thus increasing its output over three times. From 1919 to 1931 its cost of sales followed a very consistent trend in relation to income as shown in Fig. 19. The annual cost of sales during these years was 87 per cent of the income from sales. Beginning with 1932 however, it departed materially from this trend. In fact, the new trend may be associated with the years 1929 to 1934. It is not always apparent in cases like this where two trends merge, just where the new trend begins in time. It is obvious however, that as the business declined during the depression, the company did not adjust its cost of sales to income.

2 Childs Company

This famous chain of restaurants is approximately twice as large as the Waldorf System, measured in terms of the maximum income received in 1929, but its income declined more rapidly during the depression, from 30 million dollars in 1929 to about $16^1/_4$ million in 1933, a drop of 45 per cent, while the Waldorf System dropped only 22.5 per cent.

The relation of cost of sales and general expense, excluding depreciation, to total sales, for this company, is shown in Fig. 20. From 1920 to 1927 the trend of these expenses was

Annual expenses = $500,000 + (86 per cent of total sales)

During the depression when sales declined it followed a new trend of

Annual expenses = $1,000,000 + (89 per cent of total sales)

Thus it increased its annual fixed costs by $500,000 and its variable expenses by 3 per cent.

G Department Stores

There are two general types of department stores considered in this survey. The one type, represented by the May Department Stores Company does a standard retail business, and the other type represented by Montgomery Ward & Company, Inc. does both a mail-order and standard retail business, although the establishment of its retail stores is of recent origin; the company originally doing a mail-order business exclusively.

1 May Department Stores Company

The relation between income and total expense for this company from 1913 to 1934 is shown in Fig. 21. From 1913 to 1929 the annual net sales of this company grew from approximately 25 million dollars to over 111 million dollars. During this entire period of 17 years it maintained average total expenses at approximately 93.5 per cent of net sales, although in 1928 and 1929 its expenses exceeded this proportion. In fact, from 1928 to 1934 it shows a distinctly new trend of

Avg annual total expenses = $5,000,000 + (91 per cent of net sales)

2 Montgomery Ward & Company, Inc.

This company experienced a very rapid growth in business from 1912 to 1929 as shown in Fig. 22. Its sales in 1912 were less than 10 million dollars, but in 1929 they reached over 266 million dollars. Its total expenses during this period of growth followed closely the trend of 95 per cent of net sales. When sales began to decline in 1930, 1931, and 1932, the company apparently did not adjust its expenses to meet the declining sales income and consequently suffered losses in these years. In 1933 however, it began to make the necessary adjustments in its expenses so that by 1934 its expenses approached appreciably the old trend. The behavior of the expense line in relation to income shown by this company is typical of those of many businesses during the depression. It may be caused by a reduction in the unit selling price of the merchandise, or the failure to reduce expenses as sales decline, or to both situations.

3 R. H. Macy & Company, Inc.

This company operates one of the largest stores in New York City. The record of its total expenses to total sales shown in Fig. 23 indicates that from 1921 when sales were approximately $46^1/_2$ million dollars, to 1929 when they were about 136 million, the trend of expense was

Avg annual total expense = $2,500,000 + (90 per cent of total sales)

The greatest departure from this trend was in 1929 in which year the company began to experience a decline in its profit margin. From 1930 to 1934 during a period of sales decline with a slight rebound in 1934, a new trend in expense appears, which is

Avg annual total expense = $13,000,000 + (86.3 per cent of total sales)

If this trend is characteristic of the company's future operations, it appears that it must now do an annual business of about 95 million dollars to break even.

H Miscellaneous Businesses

1 Congress Cigar Company, Inc.

The earnings history of this business for the period 1922 to 1934 is shown in Fig. 24. Doing a business of more than 7 million dollars a year in 1922 the company in three years increased its annual sales to 17 million dollars. During this period, total expenses were maintained at a uniform rate with sales. With slight increases in sales in 1926 and 1927 the company decreased expenses and when sales took a downward trend in 1928, the company materially improved its margin of profit. In 1933 and 1934 sales dropped to almost $3^1/_2$ million dollars annually. During the entire period of decline the total expenses were controlled to follow the trend

Avg annual total expenses = $850,000 + (78.3 per cent of net sales)

The greater spread between total expenses and net sales during the depression period shown by this company is in sharp contrast to the experiences of many other businesses during the same period, as for example, the case which follows.

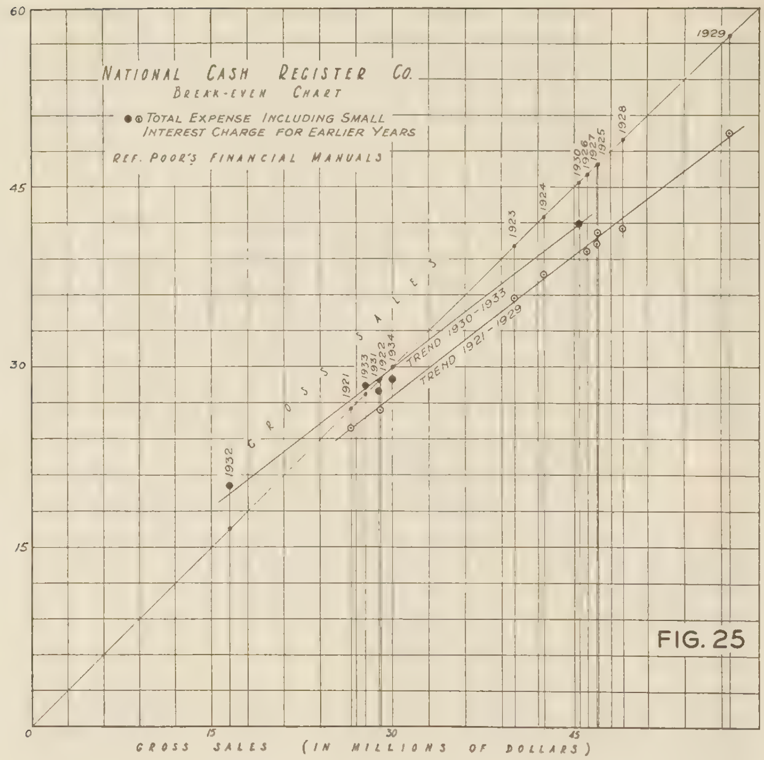


FIG. 25

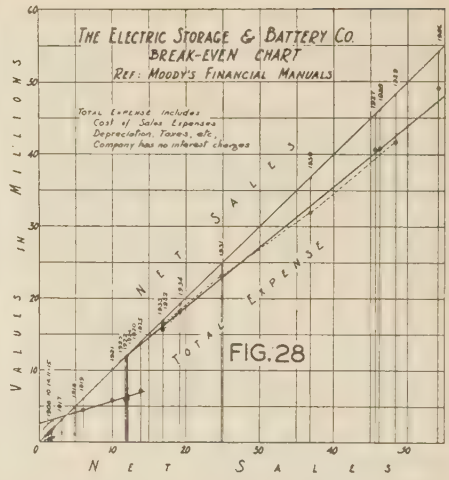


FIG. 28

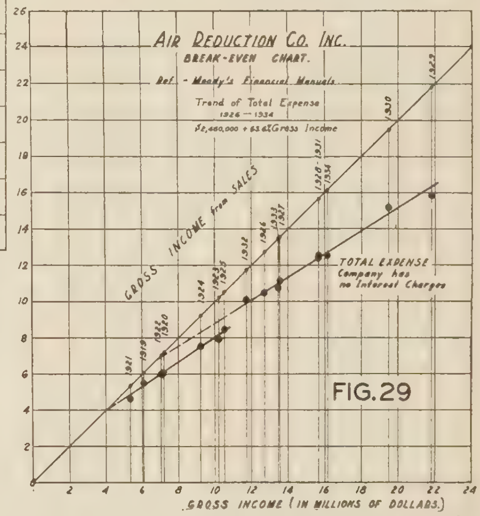


FIG. 29

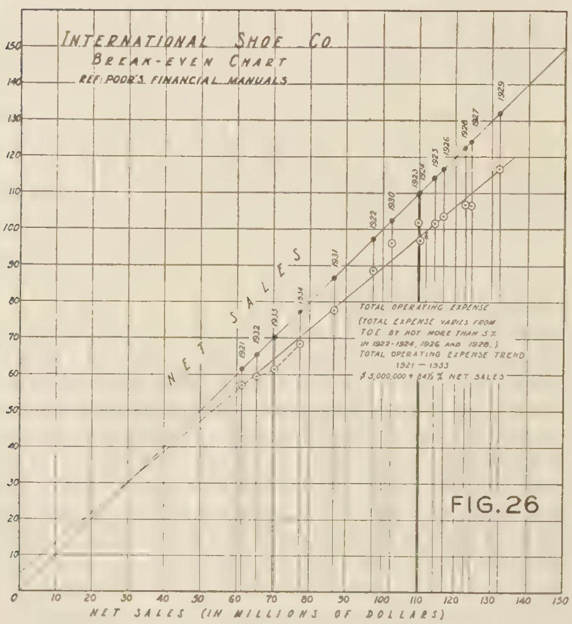


FIG. 26

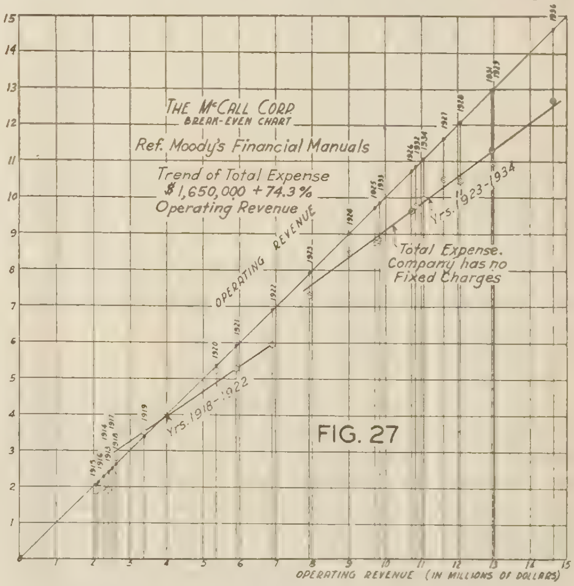


FIG. 27

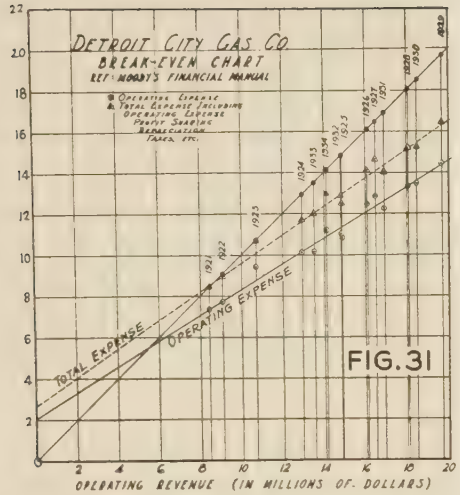


FIG. 31

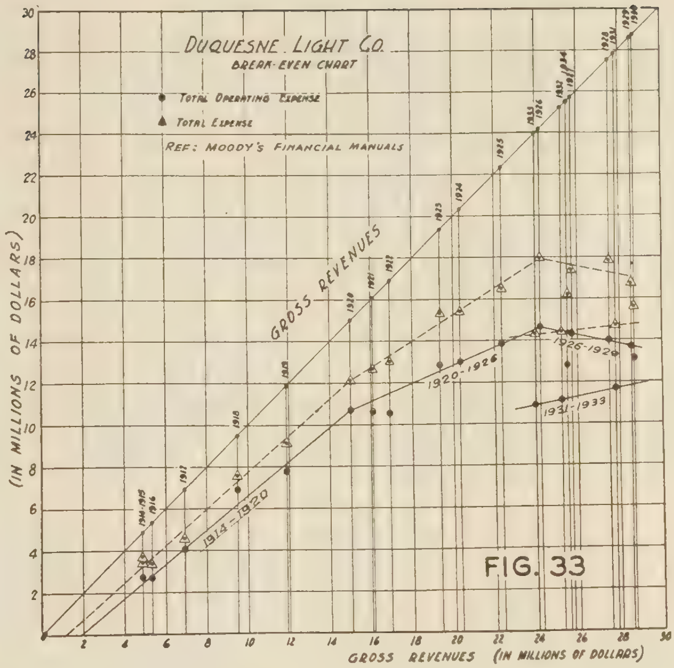


FIG. 33

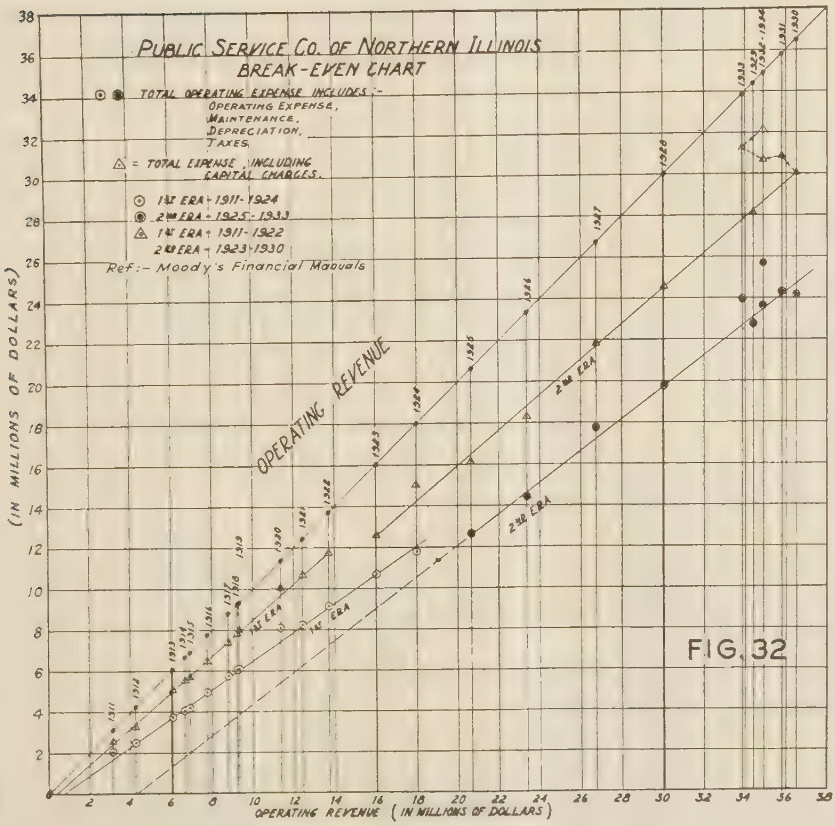


FIG. 32

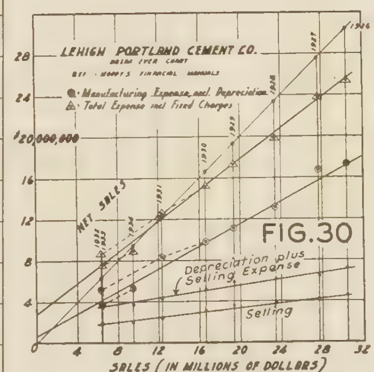


FIG. 30

2 National Cash Register Co.

As indicated in Fig. 25, this company shows two distinct trends of total expense to gross sales since 1921. Beginning with that year and extending to 1929 during which period its sales increased from less than 27 million dollars per year to over 48 million per year, it maintained an expense trend of

Avg annual total expense = \$4,000,000 + (78.33 per cent of gross sales)

In 1930 its sales dropped 21 per cent from the 1929 peak and its expense also followed a new trend for the four-year period 1930 to 1933. This trend was

Avg annual total expense = \$6,600,000 + (78 per cent of gross sales)

In 1931 however, the annual total expenses dropped below this trend, and again in 1934. Since this chart was constructed, the company reported its sales and net profits for the 12-month periods closing June 30, 1935 and 1936, in the New York Times of July 24, 1936. This report shows

	1935	1936
Sales	\$31,351,807	\$38,554,471
Net profit	810,597	1,981,509
Total expenses	30,541,210	36,572,962

According to the foregoing equation, the average annual total expense for the years should be for 1935, \$31,150,000; and 1936, \$36,600,000. It appears therefore, that the company is following closely the trend of total expense which was predicted in 1934.

3 International Shoe Co.

The reports of this company from 1921 to 1934 for annual total operating expenses in relation to annual net sales are recorded in Fig. 26. As this chart shows, the trend of expense is quite uniform for the entire period under review with only the expenses for the years 1923, 1927, 1930, and 1933 materially out of line. The general trend is

Avg annual operating expense = \$5,000,000 + (84.5 per cent of net sales)

The company has a very low break-even point, approximately at \$32,000,000 annual net sales, which is about 40 per cent of its 1929 output.

4 McCall Corporation

This company shows a rather unorganized relationship of total expense to operating revenue for the years 1913 to 1918 when its annual operating revenue fluctuated between 2 and $2^1/_2$ million dollars. As indicated in Fig. 27, with a rapid expansion of sales after 1918, there was a more definite trend of expense for the next four years when operating revenue rose to less than 7 million dollars for the year 1922. As income continued to rise from less than 8 million dollars in 1923 to over $14^1/_2$ million in 1930, there was developed a new and more uniform trend in expenses which also held during the decline in income to less than 10 million dollars in 1933 and its subsequent rise to over 11 million dollars in 1934. This trend of total expense which has persisted for 12 years is

Avg annual total expense = \$1,650,000 + (74.3 per cent of operating revenue)

This company may therefore be expected to break even at an annual operating revenue of about 64 million dollars which is approximately 44 per cent of the 1930 revenue.

5 The Electric Storage Battery Company

This company shows a rather interesting series of developments as shown in Fig. 28. From 1908 to 1918 the company did a comparatively small volume of business. In 1919 its income increased about 25 per cent over 1918, but its expenses increased about $4^1/_2$ times. From 1919 to 1925 the company more than doubled its sales and followed a new expense trend. Accordingly, as the chart shows, when it had net sales of 10 million dollars in 1921 it made only about the same profit as it did in 1918 when its sales were less than half this amount. In 1926 the company's sales increased to about 54 million dollars compared to approximately 14 million in 1925, but its profits were only about 75 per cent of those in 1925. Its total assets however, did not increase being approximately $44^1/_2$ million dollars in both years, therefore there was not occasion for higher fixed costs due to investments in plant and equipment. This was the peak in sales for this company. They dropped in 1927, regained slightly in 1928 and 1929, and then declined to less than 17 million dollars in 1932 and 1933. The trend of total expenses for the period 1926 to 1934 is

Avg annual total expense = \$2,000,000 + (84 per cent of net sales)

On the basis of this trend the company breaks even at annual net sales of \$12,500,000. It is interesting to note that for the four years 1920, 1922, 1923, and 1924, the company's sales were approximately this amount each year and at that time the profits were about 6 million dollars each year.

6 Air Reduction Company, Inc.

For the period 1926 to 1934 the total expenses of this company followed a very definite and uniform trend in relation to gross income from sales. As shown in Fig. 29 this trend is

Avg annual total expense = \$2,450,000 + (63.6 per cent gross income)

According to this trend the company should break even at about \$6,750,000.

7 Lehigh Portland Cement Company

This company did its maximum business in 1926 when its sales were over 30 million dollars. Since then, in common with other companies in the same industry, its sales fell rapidly. In 1932 they were only 21 per cent of what they were in 1926. However in this entire period, its expenses followed a generally uniform relation to income, as shown in Fig. 30. This chart shows not only the trend of total expense, with sales, but also the manufacturing expense and selling expense. It is not at all unlikely that this company will follow the expense trends shown on the chart as its sales increase in time. In that event, the trend of expenses will be

Avg annual total expense = \$2,800,000 + (75 per cent of net sales)
Avg annual manufacturing expense = \$600,000 + (55 per cent of net sales)
Avg annual selling expense = \$900,000 + (11.5 per cent of net sales)

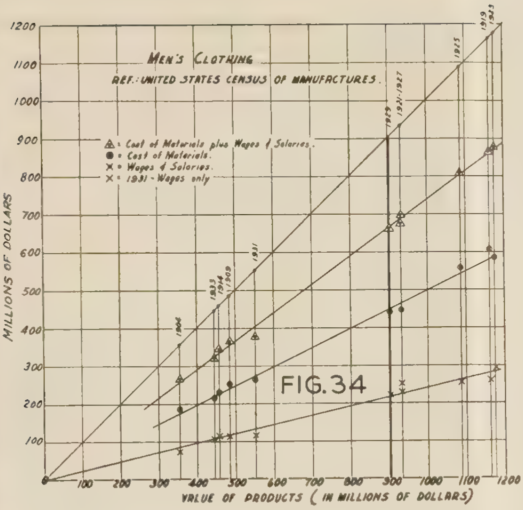
Its break-even point should be at about \$11,200,000 annual net sales.

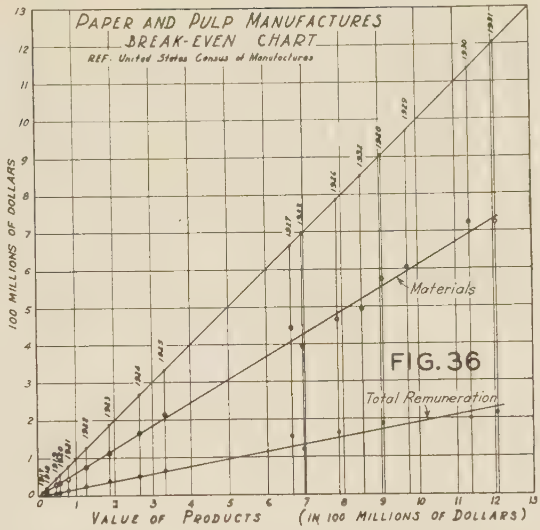
I The Utilities

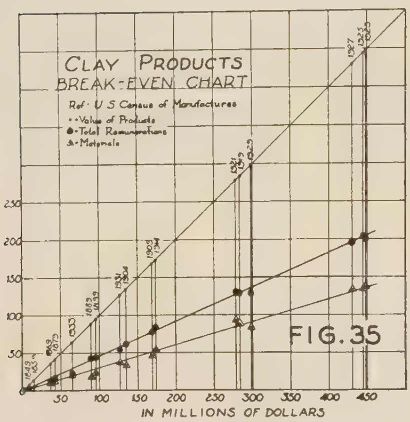
This group of industries differs from the manufacturing and merchandising businesses in many important particulars, and yet all show the same type of relationship between total expenses and income.

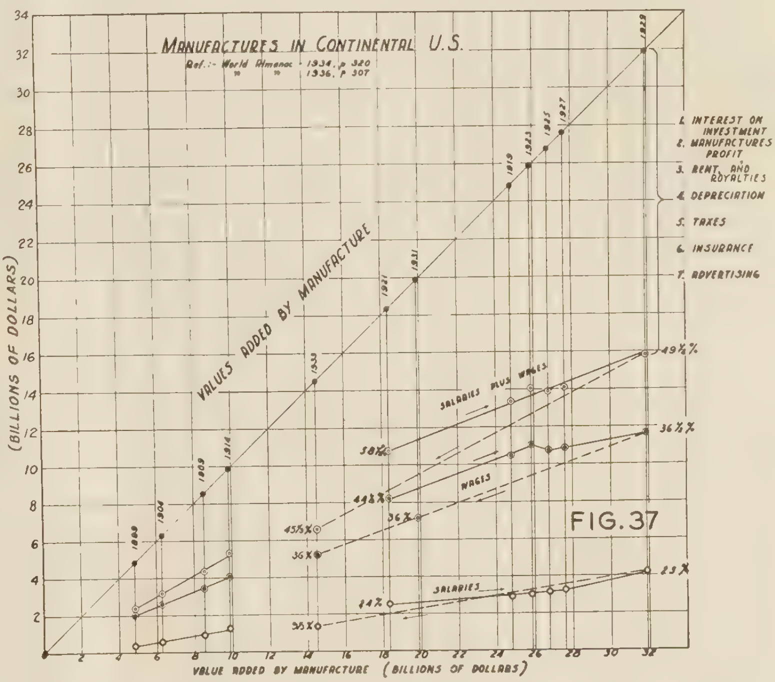
1 Detroit City Gas Company

The records of income and expense of this company from 1921 to 1934 are plotted in Fig. 31. This chart shows









Avg annual operating expense = \$2,000,000 + (62.6 per cent of operating revenue), and

Avg annual total expense = \$2,650,000 + (59.25 per cent of operating revenue), from which we find

Avg annual net earnings = (40.75 per cent of operating revenue)—\$2,650,000

From 1924 to 1933 the total assets of this company have increased from 40 million dollars to 72 million dollars. Accordingly while the net earnings in 1924 and in 1933 follow the same trend line as indicated in the chart, that is, the profit per dollar of operating revenue follows the same general relationship in 1933 as in 1924, in terms of invested capital, the company was in a less favorable position in 1933 than in 1924.

3 Public Service Company of Northern Illinois

The operations of this company in terms of income and expense from 1911 to 1934 are recorded in Fig. 32. Both total operating expenses and total expenses including capital charges are shown in relation to operating revenue. From 1911 to 1922 while the company's annual revenue increased from about \$3,000,000 to almost \$14,000,000 the increase in expenses with revenue was quite uniform. Operating expenses continued their trend in 1923–1924 but capital charges in 1923 were reduced while in 1924 they appeared again in the same trend. From 1925 to 1930 the company's annual revenue increased from over 20 million dollars to over 36 million dollars and both operating expenses and total expenses followed new trends. The spread between revenue and expenses increased during this period. From 1931 to 1934 revenue declined and while operating expenses declined along the trend line for the year 1931 total expenses rose sharply after which both operating and total expenses continued to increase without much change in revenue. In 1929 the total

assets of the company were 190 million dollars while in 1933 they were over 227 million.

3 Duquesne Light Company

The records of this company plotted in Fig. 33 show how a company may alter its economic characteristics in time. From 1914 to 1920 both operating expense and total expense follow fairly consistent trends with respect to gross revenues. After 1920 and up to 1926, the company increased its business but with a much greater spread between revenue and expenses. We have no history of operations of this company but since it is not likely that an increase in rates is responsible for this change the probabilities are that it brought about marked economies in operating conditions. After 1926 and up to and including 1929 the company effected a very marked reduction in operating expenses and continued these reductions during 1931 to 1933 while gross revenues declined. The fact that operating expenses increased materially in 1934 over the record of 1931–1933 can only be explained by an examination of the details of operating expense which are not available.

H Whole Industries

1 Men's Clothing

The production of this industry from 1904 to 1933 is shown in Fig. 34. It is interesting to observe that production in terms of dollars reached its peak in this industry in 1923 since when it has declined to almost $^1/_3$ of its maximum value. In this entire period of 30 years the average annual costs are

Wages and salaries	=	24 per cent value of product
Materials	=	50 per cent value of product

2 Clay Products

This industry also produced its maximum value of products in 1923 since when it declined in 1933 to about one ninth of its maximum. From 1929 to 1933 materials cost in relation to value of product has followed the general trend.

Average annual material cost = 30 per cent of value of product

and the trend in total remuneration has been, for 1889 to 1929

Average annual remuneration = 46 per cent of value of product

From 1929 to 1931 it fell to 43 per cent while in 1933 it fell to about 36 per cent. The records of this industry are shown in Fig. 35.

3 Pulp and Paper Manufacture

In terms of value of products this industry has had a remarkable growth since 1917, as shown in Fig. 36. As a distributor of wages and salaries it does not rank high, the general trend being

Average annual remuneration = 19 per cent of value of products

The reason for the low relative remuneration appears in the high cost of materials which is

Average annual materials cost = 61 per cent value of product

4 Manufactures in Continental United States

The value of the products manufactured in the United States together with materials, wage, and salary costs from 1899 to 1933 are shown in Fig. 37. Before 1929 the cost of materials averaged 58 per cent of the value of the products. From 1929 to 1933 the annual value of products fell from over 70 billion dollars to over 31 billion and the average cost of materials was 53 per cent during that period. With the exception of 1921, the average wage plus salaries was close to 22 per cent of the value of the products, both before and during the depression.

Modern Locomotive and Axle-Testing Equipment

By T. V. BUCKWALTER,[1] O. J. HORGER,[2] and W. C. SANDERS,[3] CANTON, OHIO

This paper shows how improvements have been made in the running and driving gear of existing and new steam locomotives to permit their operation at much higher speeds than is the usual practice today in both freight and passenger service. Means of obtaining these improvements are described whereby (*a*) the reciprocating parts are reduced in weight up to 1072 lb or 52 per cent, (*b*) the rotating parts on the main driving wheel are also reduced in weight up to 300 lb or 19 per cent, and (*c*) roller bearings are used on all axles and crankpins. As a result of such improvements, the dynamic augment on the rail and shaking forces on the locomotive and track structure at a given speed are reduced. The extent of this reduction is such that a speed increase of at least 35 mph above the diameter speed may be permitted without increasing the dynamic augment on the rails above its original value.

A program and facilities are described for the fatigue testing of full-size driver-axle assemblies with wheel-seat diameters of $11^1/_2$ in. Preliminary results indicate that valuable contributions will be forthcoming as to the influence of various designs, steels, and heat-treatments upon the axle fatigue strength.

The factors of unsprung weight and axle rigidity are not now considered in calculations of axle stresses. These factors influence the impact stresses in axles at prevailing high speeds and, to minimize the detrimental effect of such stresses, it is recommended that greater flexibility be designed in the axle by decreasing the present ratio of the axle diameter in the portion between the wheels to the diameter of the wheel seat.

High-Speed Operation of Steam Locomotives

The steam locomotive represents the lowest first cost per horsepower of motive-power units, and this fact in addition to its reliability and versatility of power has made difficult its displacement by other forms of motive power. Lately, however, competition is requiring design modifications which are not in general use today if the steam locomotive is to meet the operating requirements at the ever-increasing high speeds in both freight and passenger service.

This paper discusses the development and research problems involved in such design modifications, and deals with the mechanical equipment of the steam locomotive. The general objects of such improvements for high-speed operation are to obtain (*a*) reduced dynamic augment on the rails due to rotating and reciprocating parts so that it will not be detrimental to the existing track structure; (*b*) improved movement of the locomotive over the track by reducing nosing and fore-and-aft vibrations, thereby reducing the forces and maintenance costs on locomotive parts and track structure; (*c*) increased availability; (*d*) reduced operating maintenance cost; (*e*) greater acceleration; (*f*) increased speeds; and (*g*) increased tractive effort.

The Timken Roller Bearing Company has been dealing for years with the problems of obtaining these desired improvements in operating characteristics. Cooperation of various railroads in this development work has resulted in modifications in locomotive design incorporating the application of (*a*) lightweight reciprocating parts, including the piston, piston rod, and crosshead assembly; (*b*) lightweight main and side rods; (*c*) roller-bearing crosshead pins, main pins, side pins; (*d*) roller-bearing-equipped driver, trailer, engine- and tender-truck axles.

The beneficial results effected in locomotive operation through the application of Timken bearings to all axles are generally recognized. This is apparent from the fact that very few locomotives are being built or rebuilt which are not roller-bearing-equipped, so little will be mentioned here of item (*d*). We will therefore confine our discussion to the application of items (*a*), (*b*), and (*c*). At the time of this writing, two main-line high-speed steam passenger locomotives have been in road service for some time with Timken lightweight revolving and reciprocating parts, including Timken-bearing-equipped crankpins and wrist pins. Service results have justified the extension of these applications to 53

[1] Vice-President, Timken Roller Bearing Company. Mem. A.S.M.E. Mr. Buckwalter entered the employ of the Pennsylvania Railroad at the Altoona Works in 1900, and after six years of shop experience transferred to the motive-power engineering department, continuing work on automotive-engineering matters until 1916. He developed electric baggage, mail, and express trucks generally used at railway terminals throughout the world. He was chief engineer of the Timken Roller Bearing Company from 1916 to 1922, and has been vice-president since 1923.

[2] Research Engineer, Timken Roller Bearing Company. Dr. Horger was graduated with a B.S. degree from the Carnegie Institute of Technology in 1923. Since October, 1923, he has been employed by the Timken Roller Bearing Co. During this time he spent three years in graduate study and research work at the University of Michigan under Prof. S. Timoshenko and received his M.S.E. degree in 1934 and Sc.D. degree in 1935. He is now in charge of applied mechanics research.

[3] General Manager, Timken Railway Division, Timken Roller Bearing Company. Mem. A.S.M.E. Colonel Sanders entered railroad work in 1908 as machinist's apprentice, Central of Georgia Railway, Cedartown, Georgia, and later attended Mercer University. He was employed as machinist in the Central of Georgia Railway shops, Macon, Georgia, and Atlantic Coast Line Railroad shops, Waycross, Ga., and then in the mechanical engineer's office, A.C.L. R.R., Wilmington, N. C. He served in France with the heavy artillery and Corps of Engineers and was graduated from the French Tractor Artillery School. Returning from France, he took a position with the equipment engineering department, New York Central Railroad. In May, 1923, he became associated with the Timken Roller Bearing Company as engineer of railway equipment in connection with development of Timken railway bearings. In 1931, Colonel Sanders was commended by the Assistant Secretary of War for his work on a general transportation plan for the War Department. Now Lieutenant-Colonel, U. S. Army Reserve Corps, assigned to the staff of the Assistant Secretary of War. He is the author of American articles on "Ball, Roller, and Sliding Bearings" and "Railway Rolling Stock" in the fourteenth edition of the Encyclopaedia Britannica.

Contributed by the Railroad Division for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until June 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

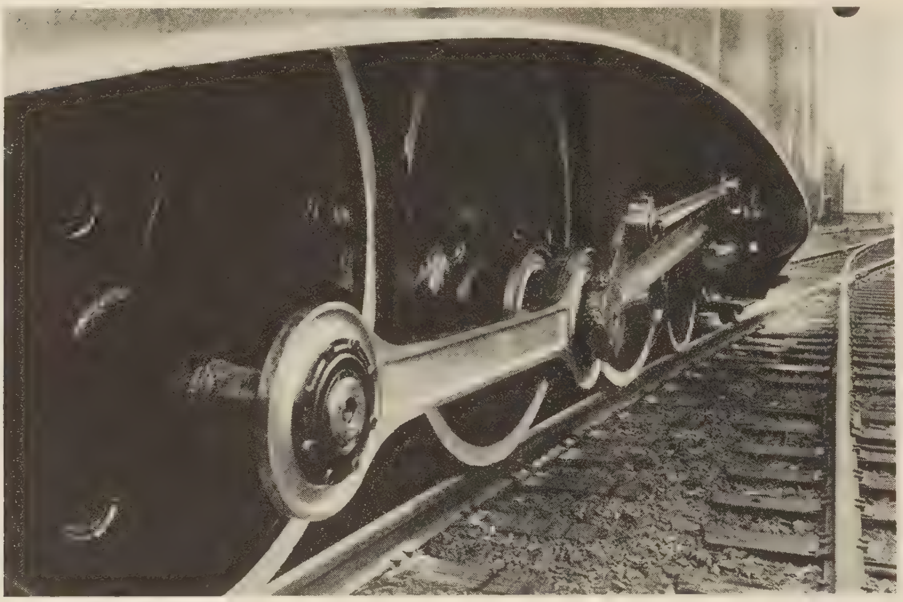


Fig. 1 The Timken Rod Application on New York Central High-Speed Streamlined Passenger Locomotive

(The crosshead and all crankpins of this locomotive were equipped with Timken bearings in 1935, and the side rods, main rods, crosshead, piston rods, and pistons are made to Timken design and of Timken steel. The use of Timken bearings and Timken high-dynamic steel in this design made possible a 52 per cent reduction of reciprocating weights, and a 22 per cent reduction of weight on the main pin. The engine-truck, and all driving and tender-truck axles have been equipped with Timken bearings since the locomotive was built in 1931. This locomotive is hauling the Twentieth Century Limited.)

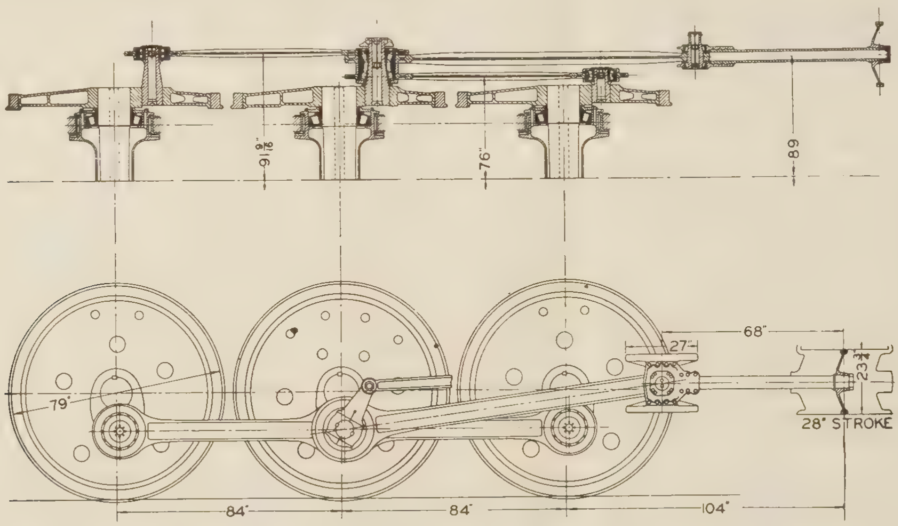


Fig. 2 Timken Lightweight Steel Driving and Running Gear for a 4–6–4 High-Speed Passenger Locomotive

additional locomotives now being built for various railroads, as indicated in Table 1 wherein locomotive specifications and road mileages are given. The influence and importance of such design changes on locomotive operation will now be discussed.

Lightweight Reciprocating and Rotating Parts

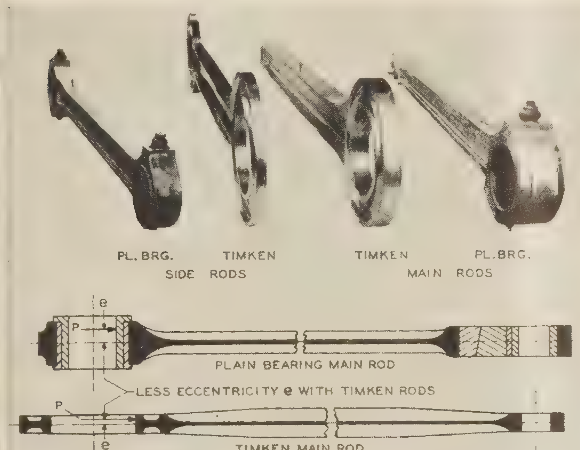
Importance of Lightweight Parts. The dynamic augment or hammer blow on the rail resulting from underbalance or overbalance of rotating parts increases with the square of the speed so that in going from 70 mph to 100 mph, a speed increase of 41 per cent, twice the dynamic augment is produced. Considering that there are certain limiting combined static and dynamic rail loads permissible on the track structure, the present motive power, with high static axle loading, does not permit doubling the dynamic augment. At diameter speed, the combined rail load is already about the permissible value.

In addition to the objectionable large dynamic augment developed at high speeds, other difficulties arise which are evidenced by increased nosing, swaying, and fore-and-aft oscillations of the locomotive. Vibrations of these types prevent smooth operation and lead to increased maintenance costs for both the track structure and the locomotive itself. The forces causing these vibrations are again proportional to the square of the speed.

Driving wheels on freight engines are frequently even too small to fully balance the rotating parts, so that the reciprocating weights remain entirely unbalanced. A large underbalance will result in excessive dynamic augment since every pound of un-

balanced rotating parts represents a rail blow of about 50 lb at diameter speed. In addition to this deleterious effect of large dynamic augment, this unbalance gives rise to horizontal forces which must be transmitted through the locomotive members and track structure. The maximum horizontal force on the locomotive frame, axle, and other parts is that due to the unbalanced rotating parts just mentioned plus that from the unbalanced reciprocating parts. This maximum force is about 70 lb for every pound of reciprocating and unbalanced rotating parts. If this force is allowed to become excessive at high speeds, additional strength in locomotive members will be required. Furthermore, these unbalanced weights result in forces producing nosing and fore-and-aft vibrations of the locomotive, although the long and heavy wheel base may tend to reduce the nosing.

The driving wheels on passenger locomotives are large enough to be properly balanced for all rotating weights and an ample percentage of the reciprocating parts. If a small percentage of the reciprocating parts are balanced, to favor a low dynamic augment, then the horizontal forces on the locomotive frame and running gear as well as vibrations from nosing and fore-and-aft movements would be excessive, although the use of the two-axle trailer trucks may improve the nosing condition. Thus, we come to the conclusion that counterbalancing offers no complete



COMPARISON OF ROD WEIGHTS, LBS.	SIDE RODS		MAIN ROD	
	PLAIN BRG.	TIMKEN	PLAIN BRG.	TIMKEN
WT. ON MAIN PIN	556	338	581	319
WT. ON FRONT PIN	190	150		
WT. ON REAR PIN	176	150		
WT. ON X-HEAD PIN			422	210
TOTAL	922	638	1003	529

Fig. 3 Comparison of Timken Lightweight Rod Design and Decreased Eccentricity of Loading With Plain-Bearing Rods for a 4–6–4 High-Speed Passenger Locomotive

solution to the problem since it is merely a compromise between balancing for the vertical and horizontal forces.

All this means that higher speeds will require either a reduction in the weight of the reciprocating and rotating parts, or improved and strengthened locomotive and track structure. Obviously, the former is the logical and economical procedure to follow, and such was the basis for the development of the Timken lightweight design. Weight reductions in reciprocating parts of 1072 lb per side and up to 52 per cent of the conventional designs have been made as shown in Table 1. The very favorable dynamic augment curves for the lightweight application in comparison with those for the heavy design it replaced are given in Fig. 6 for the axles of main driving wheels of locomotives given in Table 1. The curves show in general that it is possible by the reduction in weight to increase the diameter speed of steam locomotives by about 35 mph without change in dynamic augment. Curves similar to those of Fig. 6 could also be drawn to show the greatly decreased horizontal forces acting to cause vibrations and to stress the locomotive frame, axle, and other members. Means of obtaining this marked reduction in weights will now be discussed.

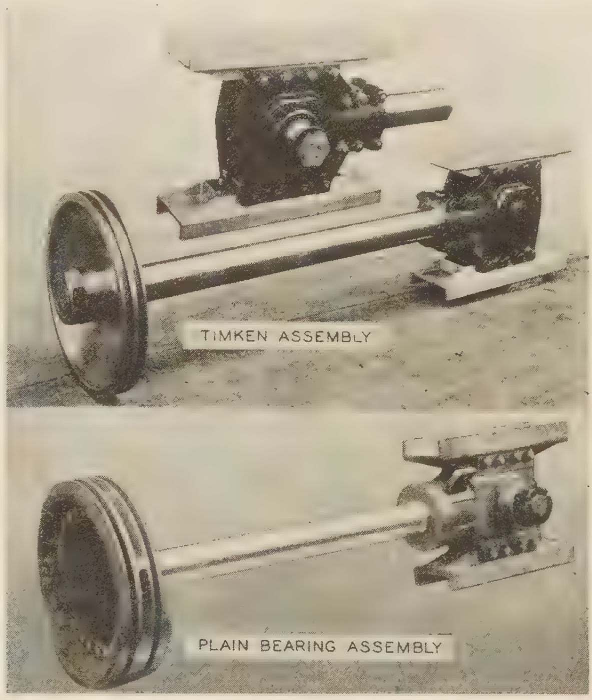


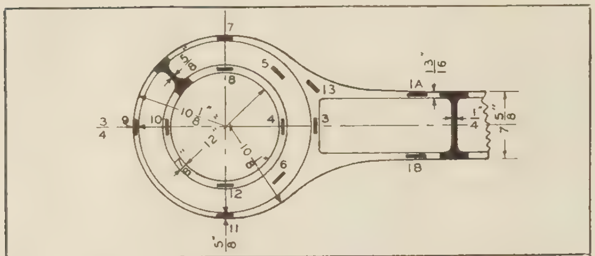
Fig. 4 Comparison of Timken Design With Conventional Design of Reciprocating Parts for a 4–6–4 High-Speed Passenger Locomotive

Comparative Reciprocating Weights

Part	Weight of plain-bearing parts, lb	Weight of Timken steel parts, lb
Crosshead assembly	754	367
Piston, piston rod, and parts	765	350
Front end of main rod	422	210
Union link and bushing	30	17
Total	1971	944
Per cent	100	48

Description of Design. The general arrangement of the application of lightweight revolving and reciprocating parts is shown diagrammatically in Fig. 2. Its application on a modern high-speed passenger locomotive is shown in Fig. 1. As a general comment it should be noted that the shape of all the parts deviate considerably from conventional design and are determined by the proper distribution of metal to give maximum strength with minimum weight so far as this is consistent with good forging and machining practice. The general details of the application are apparent from the illustrations, but several of the salient features required to accomplish this purpose will be enumerated.

The eye ends of the rods are deep and narrow-width I-sections which efficiently give considerable rigidity and low bending stresses. This feature is to be contrasted with the usual wide and heavy rectangular section required to obtain the customary low plain-bearing pressures, which contribute to large bending stresses in the column section due to eccentric loading possible



Test No.	Izod Impact Ft. Lbs.	Yield P.S.I.	Ult.Str. P.S.I.	Elong. %	Red. Area%	Izod Brinell	Tensile Brinell
1 A	64.5-61.5-64.0	123,500	138,500	21.5	59.7	285	285
1 B	64.5-64.0-66.5	123,000	138,500	22.5	61	285	293
3	53.0-54.5	124,500	140,500	19.5	55.5	285	293
4	50.5-53.5	119,500	136,500	20.5	58.3	285	285
5	55.0-56.0-55.0	123,100	138,600	20.5	59.7	285	293
6	58.5-57.0-58.0	124,000	138,000	20.0	58.3	285	293
7	57.0-58.0-55.5	127,000	140,000	21.0	59.8	285	293
8	56.5-57.0-54.0	127,500	140,000	20.0	57.3	285	293
9	46.0-47.5-46.5	126,000	140,000	19.5	52.8	285	293
10	44.5-46.5-51.5	127,000	142,000	20.0	56.5	285	293
11	58.5-59.5-57.5	127,500	140,000	20.0	56.2	285	285
12	55.5-55.5	126,000	140,500	21.0	59.1	285	293
13	62.5-64.0-63.5	122,500	139,000	21.0	61.3	285	293

Fig. 5 Uniformity of Physical Properties of Specimens Selected at Various Positions in Die-Forged Side Rod of Timken High-Dynamic Steel

over the wide ends, as indicated by a consideration of Fig. 3. The column stresses due to eccentric loading are reduced to a very low value because the narrow width of the rod ends and their simple knuckling action on the outer race of the bearing permit very little eccentricity. This knuckling action takes place on a $^3/_{16}$-in-thick rolled-strip phosphor-bronze bushing pressed into the rod eye and crowned on the surface floating over the outer bearing race. The column portion of the rods is an I-section, and, to carry the column and centrifugal stresses economically it is tapered from a center straight portion to a width of about six tenths as great at the ends. The usual knuckle-pin joints in side rods and the usual oil and grease holes through the rod eye, which introduce high local stresses and are the cause of many rod failures, have been eliminated. The rear side rod is located in a plane outside the main rod as a means of reducing the bending stresses and bearing load on the main crankpin.

The crankpins are made of thin-walled and tapered tubular sections. The crankpin bearings are of the usual Timken tapered design and are fitted directly to the crankpins. The crosshead pin also functions as the inner race of the bearing.

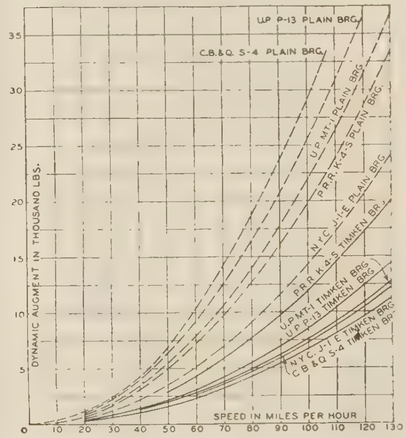


Fig. 6 Dynamic-Augment Curves for Main Drivers of Locomotives

(These curves show the reduced dynamic augment obtained by using Timken roller-bearing rotating and reciprocating parts rather than plain-bearing parts.)

TABLE 1 COMPARISON OF WEIGHTS OF REVOLVING AND RECIPROCATING PARTS, DYNAMIC AUGMENT ON RAIL, AND MAXIMUM HORIZONTAL FORCE ON LOCOMOTIVE FOR PLAIN-BEARING AND TIMKEN-BEARING-EQUIPPED LOCOMOTIVES

RAILROAD TYPE CLASS	NO. OF LOCOS	CYL. SIZE BOILER PRESS. DIA. DRIVERS	KIND OF BRG	REVOLVING WT. ON PIN, LBS. INCLUDING CRANK PIN WT (e)					RECIPROCATING WT. PER SIDE OF LOCOMOTIVE				DYNAMIC AUGMENT ON RAIL AT MAIN WHEEL IN 1000 LBS. FOR				MAXIMUM HORIZONTAL FORCE (f) ON LOCO. DUE TO UNBALANCED RECIPROCATING WT. ON BOTH SIDES OF LOCO. IN 1000 LBS. FOR			
				BACK	INT.	MAIN	FRONT	TOTAL	TOTAL WT. LBS.	% WT. BALANCED ON MAIN	TOTAL % WT. BALANCED	UNBALANCED WT., LBS	60 MPH	80 MPH	100 MPH	120 MPH	60 MPH	80 MPH	100 MPH	120 MPH
P.R.R.	1	27" X 28"	PLAIN	301		1435	285	2021	1473	19.4	58.2	615	7.2	12.8	20.1	28.9	22.0	39.1	61.0	87.9
4-6-2	(a)	205 P.S.I.	TIMKEN	417		1195	321	1933	977	17.5	52.6	464	4.3	7.7	12.0	17.3	16.6	29.5	46.1	66.4
K-4-S		80"	% DIFF.	+39		-17	+13	-4	-34			-25	-40	-40	-40	-40	-25	-25	-25	-25
N.Y.C.	1	$23\frac{3}{4}$" X 28"	PLAIN	298		1579	320	2197	1971	10.1	37.1	1239	5.2	9.2	14.4	20.7	45.3	80.7	126.0	181.4
4-6-4	(b)	250 P.S.I.	TIMKEN	441		1279	362	2082	944	10.1	37.1	595	2.5	4.4	6.8	9.8	21.8	38.7	60.5	87.2
J-1-E		79"	% DIFF.	+48		-19	+13	-5	-52			-52	-52	-52	-52	-52	-52	-52	-52	-52
N.Y.C.	50	$22\frac{1}{2}$" X 28"	PLAIN	(g)																
4-6-4	(c)	300 OR 275	TIMKEN	441		1279	362	2082	948	10.1	37.1	596	2.5	4.4	6.9	9.9	21.8	38.7	60.5	87.2
J-1-F		79"	% DIFF.																	
U.P.	1	25" X 28"	PLAIN	(g)					1510	22.2	66.6	505	9.1	16.2	25.4	36.5	19.4	34.6	54.1	77.8
4-6-2	(d)	220 P.S.I.	TIMKEN	479		1294	393	2166	1019	11.2	33.6	677	3.1	5.5	8.6	12.4	26.1	46.4	72.4	104.4
P-13		77"	% DIFF.						-32			+34	-66	-66	-66	-66	+34	+34	+34	+34
U.P.	1	29" X 28"	PLAIN	(g)					2012	17.2	51.5	976	7.8	13.9	21.8	31.4	41.8	74.4	116.2	167.4
4-8-2	(d)	200 P.S.I.	TIMKEN	468	833	1510	397	3208	1083	8.3	33.3	723	2.7	4.9	7.6	10.9	31.0	55.1	86.1	123.9
MT-1		73"	% DIFF.						-46			-26	-65	-65	-65	-65	-26	-26	-26	-26
C.B.&Q.	1	25" X 28"	PLAIN	(g)					2067	19.0	57.0	888	10.4	18.5	29.0	41.7	33.3	59.2	92.5	133.2
4-8-4	(d)	250 P.S.I.	TIMKEN	437		1305	360	2102	995	10.0	29.9	698	2.6	4.7	7.3	10.5	26.2	46.5	72.7	104.8
S-4		78"	% DIFF.						-52			-21	-75	-75	-75	-75	-21	-21	-21	-21

(a) MAIN LINE PASSENGER SERVICE MILEAGE TO JAN. 1 1937, 182,000 MILES.
(b) " " " " " " " " " , 81,000 "
(c) 50 NEW LOCOMOTIVES BEING BUILT, 5 EQUIPPED AS SHOWN AND OTHER 45 WITH TIMKEN RECIPROCATING PARTS ONLY.
(d) LOCOMOTIVES BEING REBUILT.
(e) REVOLVING WEIGHT IS COMPLETELY COUNTERBALANCED ON ALL OF THE LOCOMOTIVES SHOWN IN THIS TABLE. CROSS-BALANCING IS USED ON ALL EXCEPT THE P.R.R. K-4-S LOCOMOTIVE WHERE A STATIC BALANCE IS USED ON BOTH THE TIMKEN AND PLAIN BEARING DESIGNS IN ACCORDANCE WITH THE PRACTICE OF THE P.R.R.
(f) OCCURING WHEN CRANK PINS ON BOTH SIDES OF LOCOMOTIVE ARE 45° FROM HORIZONTAL.
(g) NOT AVAILABLE.

TABLE 2 AVERAGE PHYSICAL PROPERTIES AND STRENGTH-WEIGHT FACTORS OF HIGH-DYNAMIC AND PLAIN CARBON STEELS

Properties	Timken high-dynamic Cr-Ni-Mo	Plain carbon, A.A.R. spec.	Aluminum alloy, 25 ST[a]
Yield point, lb per sq in.	115,000	55,000	35,100
Strength-weight ratio	14.70	7.00	12.70
Tensile strength, lb per sq in.	132,000	90,000	55,100
Strength-weight ratio	16.80	11.50	19.90
Endurance limit, lb per sq in.	62,000	39,000	12,600
Strength-weight ratio	7.90	5.00	4.60
Elongation in 2 in., per cent	22.00	28.00	13.70
Reduction in area, per cent	65.00	50.00	.....
Brinell hardness	285.00	160.00	110.00
Specific gravity	7.85	7.85	2.77

[a] See reference (1) in Bibliography.

The piston rod is a thin-walled tube. The usual massive one-piece cast-steel crosshead is entirely redesigned, eliminating the taper-key connection and using a two-piece construction of thick plates die forged to proper shape. The conical piston is a forged and rolled shape of comparatively thin sections and its extremely low weight permits very successful operation with only two piston rings. The thin plate section of the piston permits deflections several times as great as the usual piston, and this is of value in reducing stresses when water is carried over from the boiler or from condensation in the cylinder. Comparison photographs of reciprocating assemblies for the conventional and Timken lightweight designs are shown in Fig. 4.

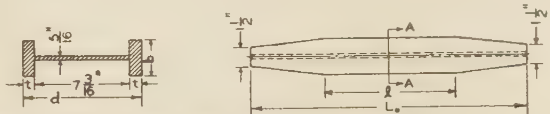
Before such service applications could be made on the driving and running gear it was necessary to give considerable study to (*a*) the selection of the proper materials and heat-treatment, (*b*) methods of manufacture, and (*c*) testing to facilitate stress analysis of the various members. This development, and particularly the testing, will be discussed in the first part of this paper, while the latter part will describe the fatigue testing of full-size driver axles as a means of reducing the stress concentration at wheel and bearing seats and increasing the fatigue strength of axles.

Selection of Material. The material selected for the rods, pistons, and principal members constituting the revolving and reciprocating parts is Timken high-dynamic steel of a Cr-Ni-Mo type, having the following nominal chemical analysis: 0.37 per cent C; 0.70 per cent Mn; 0.27 per cent Si; 0.75 per cent Cr; 1.60 per cent Ni; 0.25 per cent Mo. The approximate heat-treatment of all steel parts is a quench in caustic-soda solution or oil at 1440 F, after which a tempering treatment at 1200 F is given.

The average physical properties of this steel are shown in Table 2, and for comparison purposes similar properties are given for an aluminum alloy (1)[4] and for plain-carbon-steel forgings in accordance with A.A.R. specifications. The purpose of such a comparison is to show reasons for the selection of high-dynamic steel. In design parts of this nature it is desired to have a material possessing high yield strength, high endurance limit, good ductility as measured by elongation and reduction in area, favorable impact strength, and to obtain these properties with minimum weight as expressed by the strength-weight factors. Also good forging, heat-treating, and machining characteristics are required.

Commenting on Table 2, we find the favorable high values of strength-weight factors for Cr-Ni-Mo steel relative to yield strength and endurance limit. The value of the tensile strength is not of much importance because failure in such design parts is based on static stresses which cause yielding[5] or variable stresses which develop fatigue failure.[6] The only exception to the use of the Cr-Ni-Mo steel is in the crosshead shoe, which is an aluminum forging.

Forging Process. The driving rods, piston, and crosshead are all die forged; the piston rod is made from cold-drawn steel tubing, and the crankpins are hammer forgings. In order to obtain the beneficial effects of grain flow, the development of die shape and forging technique was required. As an example of the uniform and maximum strength characteristics obtained by favorable grain flow, Fig. 5 indicates the tensile-test results of specimens selected from various positions in the eye end of a side rod, which portion presents the greatest difficulties in producing proper grain flow. A number of longitudinal etched sections of the eye were made to determine the proper grain flow so that in the subsequent machining operations the cutting would be parallel and not transverse to these flow lines. Only $1/8$ in. to $3/16$ in. of stock is left on each surface for machining, except at the rod bore where $1/4$ in. is allowed. A typical example of the die-forging process followed in making the rods will be given.



SECTION A-A

CYLINDRICAL BLOCKS WERE USED ON ENDS OF COLUMNS TO GIVE ROUND END CONDITIONS FOR THE BUCKLING TESTS

	TEST NO. 78	TEST NO. 81 & 81A	TEST NO. 88 & 88A
d = DEPTH OF SECTION, INCHES	$8\frac{15}{16}$	$8\frac{13}{16}$	[illegible]$\frac{13}{16}$
b = WIDTH OF FLANGES AT CENTER, INCHES	$2\frac{3}{4}$	$2\frac{1}{2}$	2
A = AREA OF I-SECTION AT CENTER, SQ. IN.	7.06	6.30	5.49
I = LEAST MOMENT OF INERTIA AT CENTER, IN.^{4}	3.04	2.14	1.10
R = LEAST RADIUS OF GYRATION AT CENTER = $\sqrt{I/A}$, INCHES	0.655	0.582	0.448
a = AREA OF I-SECTION AT ENDS, SQ. IN.	4.86	4.67	4.67
i = LEAST MOMENT OF INERTIA AT ENDS, IN.^{4}	0.507	0.475	0.475
ℓ = LENGTH OF UNIFORM SECTION, INCHES	58	37	37
L_0 = OVERALL LENGTH OF COLUMN, INCHES	83	83	83
ℓ/L_0	0.70	0.45	0.45
i/I	0.166	0.220	0.431
m = DINNIK'S FACTOR	9.58	8.80	9.28
P_c = BUCKLING LOAD FOR COLUMN = mEI/L_0^2, LBS.	127,000	81,500	45,400
P_c/A = AVE. COMPRESSIVE STRESS AT CENTER, P.S.I.	18,000	12,900	8,300
L = LENGTH OF UNIFORM COLUMN WHICH WOULD HAVE THE SAME BUCKLING LOAD, INCHES	84.2	87.8	85.5
L/R = SLENDERNESS RATIO	128.5	150.8	191.0
P = BUCKLING LOAD FROM TEST, LBS.	127,000	82,000	49,500

FIG. 7 TAPERED-COLUMN TEST RESULTS

The eye end and a little over half of the column section of the rod is die forged in three operations consisting of forming, blocking, and finishing operations. The opposite end of the rod is then die forged in a similar manner. A center die is then used to straighten the column section with the ends and to control the length.

The forming begins by hot upsetting the end of a 7-in. round billet into a sphere after which this sphere is flattened into a pancake-shape in the plane of the rod. This blank is then placed in a 1500-ton hydraulic press for the blocking operation where it is pressed into the die shape of the column and eye sections. The final forging is then done in finishing dies on an 18,000-lb drop hammer. The proper temperature of the forging must be maintained during each of these operations by reheating. A steam jet is used to remove all scale after each hammer blow.

The trimming of the flash is done in three operations. The thin plate left in the bore of the eye is removed after the blocking, the outer flash is removed after the completion of one half

[4] Numbers in parentheses refer to the Bibliography at the end of the paper.

[5] The reason for the favorable influence of high yield strength is discussed later in the paper under column design of rods.

[6] As an example, variable stresses occur in the eye-end sections of the rods; this is discussed later in the paper

the finish forging, and final trim is made after completion of the forging. The total weight of the trim is very small. A complete description of this forging process is given in *Iron Age* (2).

Design of Column Sections of Rods

The design of the column sections of the main and side rods is based on compression tests of full-size tapered columns. The columns tested were machined from standard structural-steel I-beam sections to dimensions comparable with those of full-size main and side rods used in service. The object of these tests was to determine the load required to bring failure due either to local yielding or to buckling. Only sufficient tests were made to satisfy the validity of formulas (4) for the rational design of tapered columns.

Column Tests. The general shape and characteristics of the columns tested are shown in Fig. 7. For a column tapered in the manner shown, the least moment of inertia of any cross section in the tapered portion at either end of the column is very nearly proportional to the cube of the ratio of the width of flange at that section to the width of flange at the end of the column. The buckling load for a pin-ended column of this kind is expressed by the equation

$$P_c = m\frac{EI}{L_0^2} = m\frac{EAR^2}{L_0^2} \quad\text{[1]}$$

where E = Young's modulus (30×10^6); I = least moment of inertia of the uniform section at the center of the column; A = cross-sectional area of this section; R = least radius of gyration of the same section; L_0 = over-all length of the column; m = coefficient (Dinnik's factor) dependent on the ratios l/L_0 and i/I; l = length of uniform part of the column; and i = least moment of inertia of the section at either end of the column. Values of the coefficient m were taken from a table for pin-ended tapered columns given in Dinnik's work (4) and the buckling load was calculated for each column tested as shown in Fig. 7.

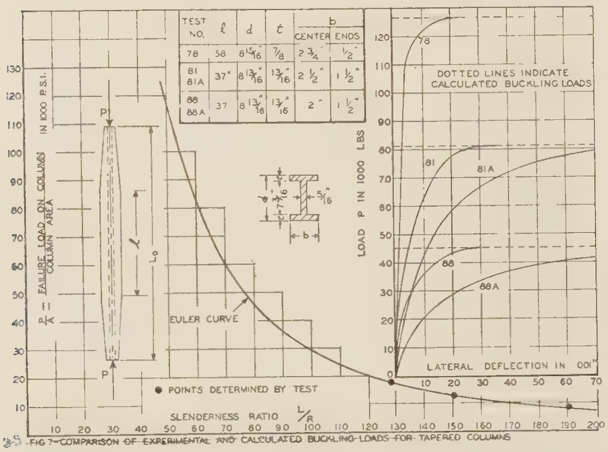


Fig. 8 Comparison of Experimental and Calculated Buckling Loads for Tapered Columns

For a uniform column, Equation [1] for the buckling load reduces to Euler's formula

$$P_c = \pi^2\frac{EI}{L^2}$$

or

$$\frac{P_c}{A} = \pi^2\frac{E}{(L/R)^2} \quad\text{[2]}$$

where L = length of the uniform column; A = cross-sectional area; and R = radius of gyration of the cross section. From Equation [2] Euler's curve has been plotted in Fig. 8. A modified Euler curve could be drawn for each value of m encountered in the column tests, and individual test results could be compared with the corresponding curves. Instead of doing this, a simpler procedure was adopted for the comparison of test values with the values predicted by theory. For each column tested, the length L was calculated for an equivalent uniform column, having a cross section the same as that of the center part of the

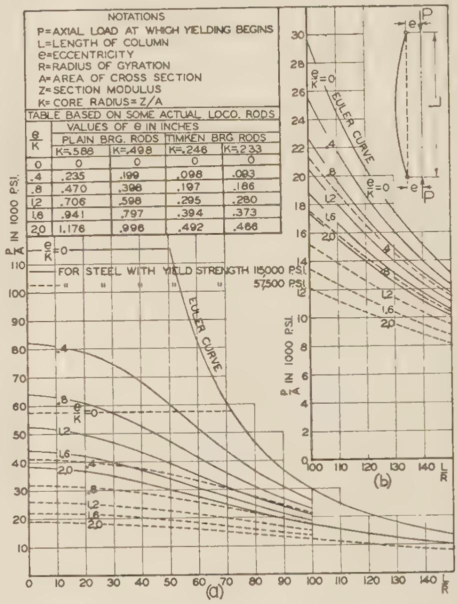


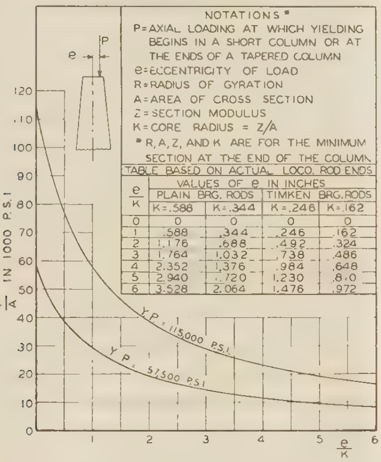
Fig. 9 Stress in Columns of Various Slenderness Ratios

(These curves show that the allowable P/A stress, above which yielding will occur at the center of an eccentrically loaded column, is greater for columns made of steel having a yield strength of 115,000 lb per sq in., than it is for columns made of steel having a yield strength of 57,500 lb per sq in.)

tapered column, which would buckle at the same load. Using this value of L, the test value of P_c/A for each column tested could be plotted against L/R for that column and the point so obtained should fall on Euler's curve.

The table in Fig. 7 gives the dimensions and other data for three of the seventeen different designs of columns tested. The test results given in this table represent the results of five tests, one test on the first design and two each on the other two designs. In each case, the buckling loads for the two tests on the same design were identical. The load-deflection curves for these five tests are given in Fig. 8. The slope of each curve showing the lateral deflection of the column at its center is due to slight and unavoidable imperfections in material, initial curvature of the column, and accidental eccentricity of the load applied in the test. For an ideal column, the curve would be truly vertical for loads up to the failure load. The actual curves are asymptotic to the horizontal dotted lines which show the theoretical calculated value of the buckling load for each column. The test value of P_c/A for each of the three designs of Fig. 7 is plotted against L/R in Fig. 8 as three points, which fall on the Euler curve. The close agreement of the experimental points with Euler's curve shows that the analytical work of Dinnik can be applied to find an equivalent value of L for a tapered column. This equivalent length will be greater than the actual length L_0 of the column, and the column may then be designed for safety from buckling or failure at the middle of the column as

though it were a uniform column of length L. The experimental results presented in this paper in support of this idea were obtained from tests on tapered columns having very little eccentricity. However, additional tests on tapered columns were carried out in which the loads were applied with a deliberate eccentricity at both ends of the column. These tests showed that the correspondence between the measured deflections at the center of an eccentrically loaded tapered column and the calculated deflections at the center of the equivalent uniform column, the



e/K	VALUES OF e IN INCHES			
	PLAIN BRG. RODS		TIMKEN BRG. RODS	
	K=.588	K=.344	K=.246	K=.162
0	0	0	0	0
1	.588	.344	.246	.162
2	1.176	.688	.492	.324
3	1.764	1.032	.738	.486
4	2.352	1.376	.984	.648
5	2.940	.720	1.230	.810
6	3.528	2.064	1.476	.972

FIG. 10 CURVES SHOWING THAT THE ALLOWABLE P/A STRESS, ABOVE WHICH YIELDING WILL OCCUR AT THE ENDS OF AN ECCENTRICALLY LOADED TAPERED COLUMN, IS GREATER FOR COLUMNS MADE OF STEEL HAVING A YIELD STRENGTH OF 115,000 LB PER SQ IN., THAN IT IS FOR COLUMNS MADE OF STEEL HAVING A YIELD STRENGTH OF 57,500 LB PER SQ IN.

length of which was determined as previously explained, was sufficiently close to warrant using the same equivalent length L for the design of a tapered column regardless of the amount of eccentricity assumed to exist in the application of loads.

Failure of Uniform Columns. With this in mind, we can proceed with a discussion of the failure of uniform columns. Euler's curve shown in Fig. 8 gives the buckling load for pin-ended columns with no eccentric loading. If we consider that a column has failed as soon as the yield-point strength has been exceeded, then the full-line curve designated as $e/k = 0$ (see Fig. 9 for notations and table of values of eccentricity e for actual locomotive rods) in Fig. 9 gives the failure loads for columns with no eccentricity if the steel in the columns is of the Timken high-dynamic type, having a yield-point strength of 115,000 lb per sq in. The horizontal portion of this curve is below the value of L/R used for locomotive rods and is not of much interest to the designer. For a detailed discussion of short columns see the paper by Westergaard and Osgood (5). In a driving-gear system, moreover, the load is sometimes eccentrically applied on the rod and develops stresses above the yield point as a result of the combination of bending stress with direct stress. The remaining full-line curves of Fig. 9 are also for a yield-point strength of 115,000 lb per sq in., and show the loads at which yielding at the center of a uniform column will begin for several assumed values of the ratio e/k. The curves shown in Fig. 9 were calculated using the equation

$$\frac{P}{A} = \frac{\text{Yield-point strength}}{1 + \frac{e}{k} \sec \frac{1}{2} \frac{L}{R} \sqrt{\left(\frac{P}{EA}\right)}} \qquad [3]$$

the notations for which are given in Fig. 9. This equation is found in a paper by Young (6). The dashed-line curves of Fig. 9 give the same information as the full-line curves, only for a steel having a yield-point strength of 57,500 lb per sq in. Fig. 9*a* shows both groups of curves for values of L/R up to 150. In Fig. 9*b* is given that portion of the curves to an enlarged vertical scale for L/R values of 100 to 150 which are commonly used in locomotive-rod design.

The curves of Fig. 9 furnish a basis for the rational design of columns by assuming some eccentricity and utilizing steels with higher yield strength. The factor of safety for any column will be the ratio of the load at which the column will yield to the maximum load which the column must carry. It is apparent from Fig. 9*b* that with equal eccentric loading (say e/k = 2.0) the higher yield strength steel will give a column strength 24 to 43 per cent greater than the lower yield strength steel for L/R ratios of 150 and 100, respectively. As mentioned before, the narrow width of the ends of the Timken rods and the well-maintained alignment of the driving axles and driving-rod system through the use of Timken roller bearings permits small eccentric loading compared to plain-bearing rods. Assuming that e/k may be reduced from 2.0 to 1.0, then Timken rods made from steel with a high yield strength will have a strength of from 40 (L/R = 150) to 76 per cent (L/R = 100) greater than plain-bearing rods of the same weight made from steel with low yield strength. Or by maintaining the same column strength in designs using both steels, the Timken rods will show a saving in weight.

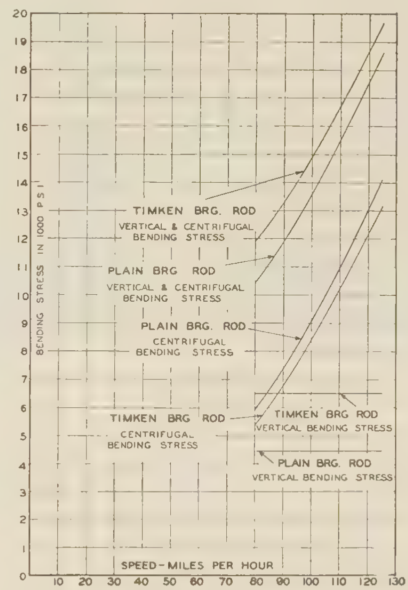


FIG. 11 VERTICAL BENDING AND CENTRIFUGAL STRESS IN MAIN RODS

Yielding at the Ends of Tapered Columns. While the curves of Fig. 9 illustrate saving in weight effected by using steel of high yield strength for uniform columns, we will also show by Fig. 10 that the use of the same steel gives additional weight saving by increasing the amount of taper which may be permitted at the ends of the columns or rods. When the ends of a column are tapered, failure may develop due to local yielding at the ends of the column before buckling or yielding occurs in the middle. The stress at the end of a column is independent of deflections, so that the maximum combined stress at the end of a tapered column is simply

$$\frac{P}{A} + \frac{Pe}{Z} \quad [4]$$

where the notations are those in Fig. 10. To find the value of P/A at which yielding will begin at the end of a column it is only necessary to equate this stress to the yield-point strength of the material. Fig. 10 gives curves showing the values of P/A at which yielding will begin at the ends of a tapered column, one curve for the Timken high dynamic steel having a yield point strength of 115,000 lb per sq in., and the other for a steel having a yield strength of 57,500 lb per sq in. The curves show that the value of P/A to cause yielding for a given column end section is directly proportional to the yield-point strength of the material

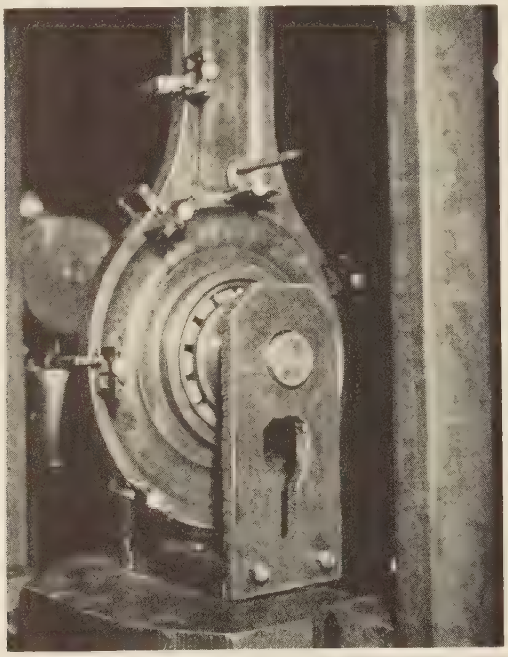


Fig. 12 Side Rod in Test Setup Showing Arrangement of Strain Gages Used to Determine Stress Distribution in Various Eye Sections

used. In using the curves in Fig. 10 it should also be considered that here again much less eccentric loading may be expected on the narrow Timken rods than on the wide plain-bearing rods for the reasons previously mentioned.

On the basis of the test results and theoretical considerations presented previously in this paper, we conclude that tapered-column sections used in locomotive main and side rods may be designed for safety against sidewise bending and direct stress by the use of curves derived from rational formulas. It should be mentioned here that empirical formulas similar to those used by A.A.R. and locomotive builders do not permit the proper evaluation of the advantages to be obtained by using the higher-yield-strength steel and tapered-column design.

Fatigue Failure of Rods. Up to this point, only static failure of the columns has been considered, but the possibility of fatigue failure must also be investigated. Fatigue failures seldom occur in the uniform-column portion of the rod, but usually develop at the junction of the column with the eye (fatigue failures in the eye will be discussed later). In this region there is usually an abrupt change in section, and the bending and direct stresses are higher than the nominally calculated values due to stress concentration. The Timken-rod design gives comparatively uniform sections at the junction of the eye and column which results in less stress concentration and greater uniformity of strength of material than in the plain-bearing rods. The danger of fatigue failure in the Timken rods is further reduced by the high fatigue strength of the high dynamic steel.

Vertical Bending and Centrifugal Stresses. At low speeds, only sidewise bending and direct stress need be considered. At high speeds, however, stresses due to vertical bending caused by the column load and inertia forces on the rods must be considered. Fig. 11 shows a comparison of these stresses for the Timken main rod on a locomotive and the plain-bearing rod which it replaced. The centrifugal stresses were calculated from the usual formula as recommended by the American Locomotive Company and the A.A.R., and derived in Merriman's "Mechanics of Materials." The formula recommended by the American Locomotive Company for the calculation of vertical bending

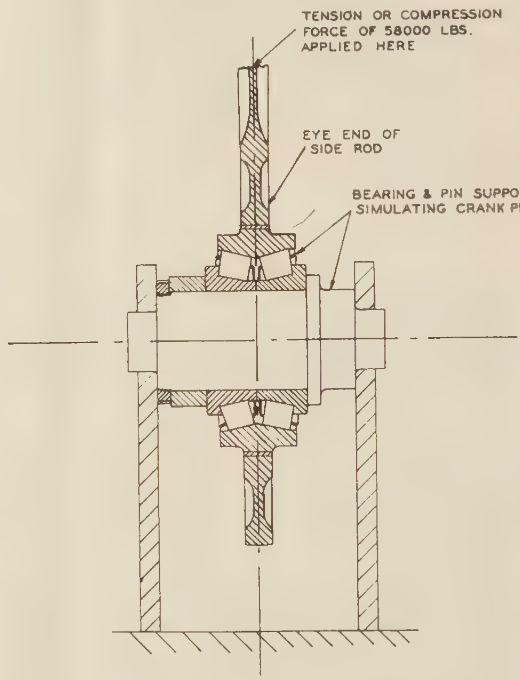


Fig. 13 Arrangement of Test Setup of Side Rod to Determine Stress in Eye Section by Means of Strain Gages

(Locations of strain gages at various positions on the eye are shown in Fig. 14.)

stress S in a rod, is an empirical formula which can be written in the form

$$S = \frac{P/2A}{1 - (P/2\,P_e)} \quad [5]$$

where P is the maximum piston thrust, and P_e is Euler's load for buckling in the vertical plane as given in Equation [2], considering the rod as a round-ended column. The curves for vertical bending stress given in Fig. 11 were calculated from this formula. Fig. 11 shows also the combined stress, vertical bending plus centrifugal, for the Timken rod and the plain-bearing rod. It will be seen that the combined stress is slightly higher for the Timken rod because of its reduced section. The higher stress in the Timken rod is more than offset by the higher physical properties of the steel used as compared with the properties of the steel used for plain-bearing rods.

The practice of combining vertical bending with centrifugal

stress, as in Fig. 11 is recommended by the American Locomotive Company. The standard practice of the A.A.R. is to combine direct stress due to a fraction of the full piston thrust with centrifugal stress. The latter method would give slightly lower stresses than those shown by the curves in Fig. 11.

Design of Eye Ends of Driving Rods

Examination of Figs. 1 and 3 showing the eye-end sections of the Timken main and side rods reveals the wide departure from usual design practice, in that light I-sections are used instead of heavy rectangular sections. On account of this great difference in shape of sections, it was not advisable to employ the established empirical formulas of the A.A.R. and locomotive builders in arriving at the proper design of eye for the Timken rods.

A satisfactory analytical solution for the stresses in the eye ends of the main and side rods does not exist. This is due to the difficulty of determining the load distribution over the bore of the rod eye which depends upon the clearance between the eye and the bearing race (7). This clearance is a minimum for new parts and, since increased clearance results in higher stresses in the eye sections of the rod, the stresses in these sections become greater as the clearance increases under operating conditions. The purpose of these static tests on full-size eye sections, therefore, was (*a*) to investigate the stress distribution in various designs of eye sections, and (*b*) to determine the increased magnitude of these stresses due to increasing the clearance from minimum to maximum values anticipated in service. These tests were made on side rods and the knowledge obtained was applied in an analytical solution for the stresses in the main rods which are of similar design. In addition to the stresses measured in these static tests, stresses due to impact are present in the eye sections under operating conditions and this must be considered when a factor of safety is selected.

Tests of Side-Rod Eyes. The method of loading the eyes of the side rod in the testing machine to determine the stress distribution by means of last-word strain gages of 1-in. gage length located at various I-sections is shown in Figs. 12 and 13. The complete stress distribution was determined in the eye section for ten different rod conditions which included the investigation of five different eye designs having various clearances between the eye and the outer race of the Timken bearing. A total of 1300 strain-gage readings were made, most of which were obtained from tensile tests on the rods and the remainder from compression tests. As shown in Fig. 13, a load of 58,000 lb (one half piston thrust) was applied on the side-rod eye in all these tests which is in accordance with A.A.R. design specifications for the six-coupled passenger locomotive on which this rod application was made. The results of two of the tension tests on each of the two designs of eyes in Fig. 14 are shown graphically in that figure. Strain gages could not be mounted closer than $^{1}/_{16}$ in. from the boundary of the rod so that stresses at this position are given in the table of Fig. 14 rather than stresses extrapolated to the boundary.

SUMMARY OF STRESSES AT SECTIONS U & N

DESIGN	PIN CLEARANCE	SECTION U STRESS P.S.I. $\frac{P}{2A}$ B	SECTION U STRESS P.S.I. BY TEST C	SECTION U RATIOS $\frac{C}{B}$	SECTION U RATIOS $\frac{D}{E}$	SECTION N STRESS P.S.I. $\frac{P}{2A}$ B	SECTION N STRESS P.S.I. BY TEST C	SECTION N RATIOS $\frac{C}{B}$	SECTION N RATIOS $\frac{D}{E}$
1	$\frac{1}{64}$"	7200	23600 E	3.28	1.20	6500	9600 E	1.48	2.17
	$\frac{5}{64}$"		28200 D	3.92			20800 D	3.20	
2	$\frac{1}{64}$"	7500	23500 E	3.13	1.13	7500	11300 E	1.51	1.67
	$\frac{5}{64}$"		26500 D	3.53			18900 D	2.52	

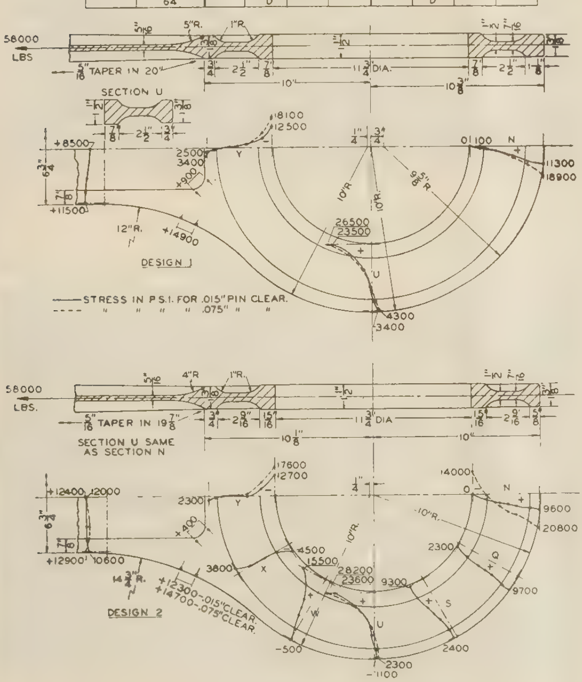


Fig. 14 Stresses and Dimensions of Side-Rod Eyes Tested

SUMMARY OF STRESSES DUE TO BOTH .004" PRESS FIT OF CROSSHEAD PIN & 117400 LBS. PULL ON MAIN ROD

	SECTION U	SECTION N
A. MEASURED STRESS P.S.I.	21800	20900
B. STRESS $\frac{P}{2A}$ P.S.I.	13000	8100
C. RATIO $\frac{A}{B}$	1.68	2.58

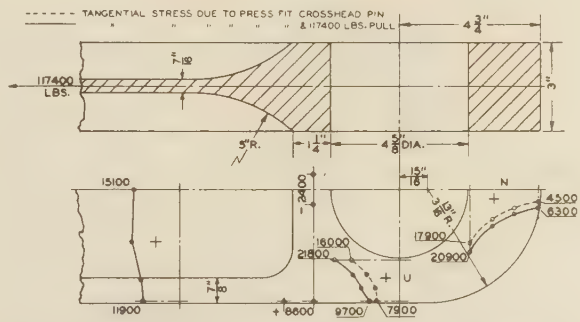


Fig. 15 Stresses in Front End of Main Rod at Crosshead-Pin Connection

Summary of Stresses Due to Both 0.004-In. Press Fit of Crosshead Pin and 117,400-Lb Pull on the Main Rod

	Section U	Section N
(*A*) Measures stress, lb per sq in.	21,800	20,900
(*B*) Stress $P/2A$, lb per sq in.	13,000	8100
(*C*) $(A)/(B)$	1.68	2.58

Referring to Fig. 14, it is apparent that the critical stresses measured in test occur at sections N and U with the latter showing the maximum stresses. Actually the maximum stresses exist a short distance from section U, depending upon the clearance in the eye, but the difference from the values shown would be small. The table in Fig. 14 shows slightly lower stresses for design 2 than for design 1, particularly with increased pin clearance. This may be explained by the increase in hub thickness from $^{7}/_{8}$ in. in design 1 to $^{15}/_{16}$ in. in design 2 and by the longer radius of $14^{3}/_{4}$ in. used in design 2 compared to 12 in. in design 1. The thinner rim in design 2 would tend to increase the stress over design 1. The effect of $^{5}/_{64}$ in. pin clearance instead of $^{1}/_{64}$ in. clearance is to increase the stresses by 13 to 20 per cent at section U, but is of greater influence at section N where the stresses with $^{5}/_{64}$ in. clearance are 1.7 to 2.2 times as great as the stresses with

$^1/_{64}$ in. clearance. The measured stresses given in the table in Fig. 14 for section U are 3.1 to 3.9 times the nominally calculated direct stresses, $P/2A$, and are 1.5 to 3.2 times as great as $P/2A$ at section N, which indicates the presence of considerable bending at these sections.

As a result of the test data given and additional tests not shown, the final design of rod introduced in service applications incorporated features of both designs 1 and 2, which would give stresses more favorable than those shown in Fig. 14.

Several investigators have made tests (1), and analytical (8, 9, 10) and photoelastic (11, 12) analyses of the stresses in eye bars. The difficulties in applying their solutions and results were principally due to the facts that their investigations were made on eye bars having rectangular sections, and that the determination of distribution of pressure around the bore as affected by pin clearance necessitates lengthy solutions. Given more time it is believed that a satisfactory correlation could be made between the stresses obtained by test and the analytical values.

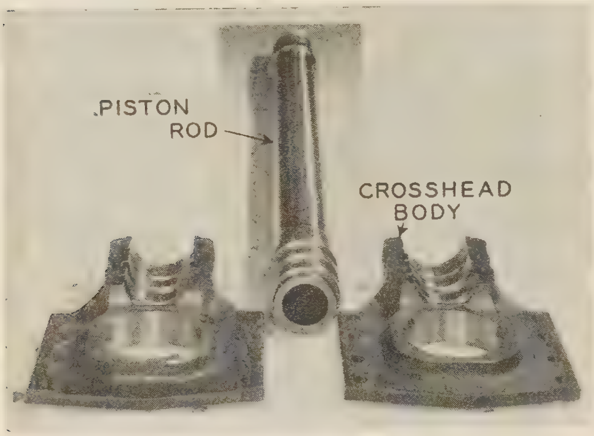


Fig. 16 Two Halves of Die-Forged Crosshead Body Bolted Together Over System of Annular Grooves in Piston Rod to Form Crosshead Connection

Tests of Front End of Main Rod. Similar strain-gage tests were also made on the front end of the main rod to determine the stresses in the rod due to both the cylinder pressure and the press fit of the crosshead pin in the rod. The results of these tests are shown in Fig. 15. The stresses in the rod resulting from the 0.004-in. press fit of the crosshead pin were measured first, and are shown by the broken-line curves in the figure. Then 117,400-lb pull was applied on the rod, increasing the stresses to the values shown by the full-line curves, which represent the combined stress due to both the press fit and the pull. The pull force on the rod increased the stress by 17 per cent at section N and 36 per cent at section U over that due to the press fit. The variation in stress in going from tension to compressive forces in the rod will therefore be small in actual operation and this is a favorable condition for maximum fatigue strength. The measured stress at section U in the bore is 1.7 times the nominally calculated direct stresses, $P/2A$, and 2.6 times at section N. The measured stresses due to the press fit give reasonable agreement with calculated values based on Lamé's formula in view of the assumptions necessary in making such a comparison.

It is necessary to maintain sufficient press fit of the pin in the rod if it is not to work loose in service. Besides the tests just mentioned additional tests were made on the front end of the main rod. The results of these tests indicate that it is desirable to make the rod eye from 0.002 in. to 0.004 in. tight on the crosshead pin.

Crosshead Test

A comparison illustration of the assemblies constituting the reciprocating parts is shown in Fig. 4 for the lightweight and conventional designs. The usual design of taper key fit of the piston rod in the cast-steel crosshead contributes considerable

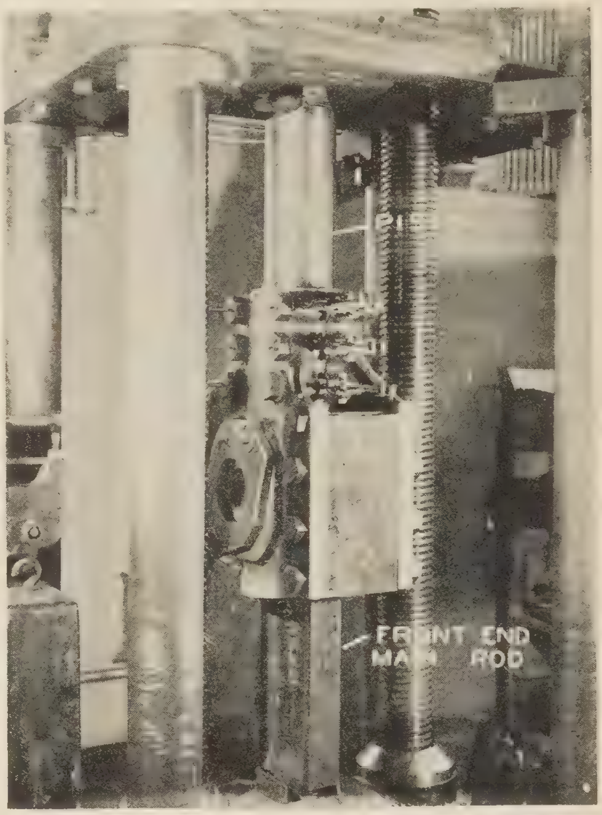


Fig. 17 Crosshead Test Setup Used to Determine Stress Distribution in Annular-Groove Connection Between Piston Rod and Crosshead

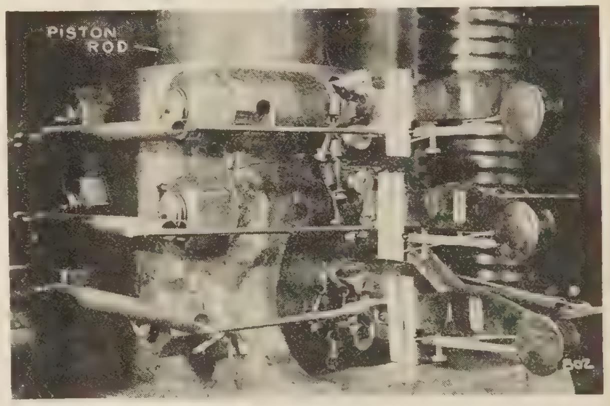


Fig. 18 Close-Up of Crosshead Test

(Illustration shows the method of determining piston-rod stresses by means of Huggenberger strain gages mounted on gage pins fixed to piston rods and extending through clearance holes in the crosshead.)

weight to the reciprocating parts and is not used in the Timken design. In this lightweight design a piston rod having a $^3/_4$-in. wall section is keyed by three integral annular grooves on

the end of the piston rod to a crosshead consisting of two thick die-forged side plates as shown in Fig. 16. The object of the following described tests was to develop the proper design and system of annular grooves to provide a rigid connection and proper distribution of load over the several annular grooves. This problem is somewhat similar to that in bolts where there is a concentration of stress in the first few threads (13, 14), and in the

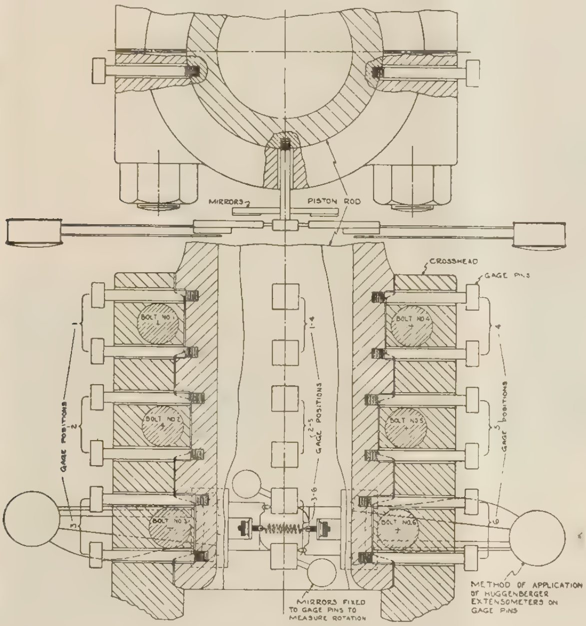


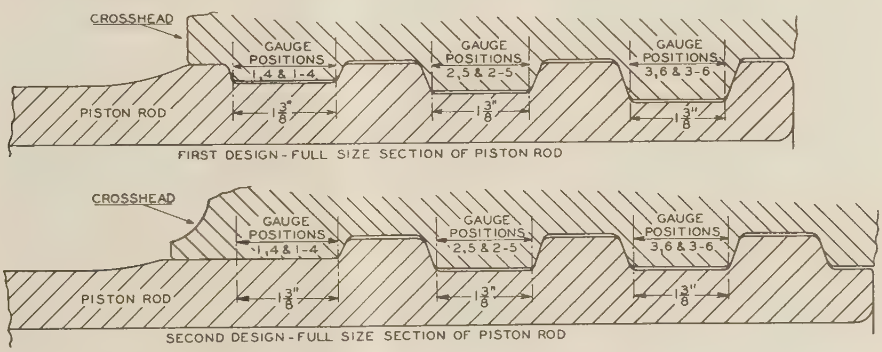
Fig. 19 Method of Mounting Huggenberger Strain Gages and Mirrors on Gage Pins Fixed to Piston Rod and Extending Through Clearance Holes in Crosshead. Used for Determining Stresses in Annular Grooves in Piston-Rod Connection at Crosshead

crosshead design the groove shape and spacing as well as shape of crosshead body was modified to give a more even stress distribution.

A general view of the crosshead assembly located in the tensile-test machine is shown in Fig. 17 and a close-up in Fig. 18. Strain measurements were obtained on the piston rod at the base of the annular grooves by means of gage pins fixed to the rod and extending through clearance holes in the crosshead as shown in Fig. 19. Huggenberger gages were then applied to the extended gage pins to measure the change in distance between pins, and telescopes were sighted on mirrors attached to the pins to determine their change in angularity. It was necessary to measure change in angularity of pins since the Huggenberger strain gages could not be mounted directly on the piston rod. By correcting the Huggenberger reading for change in angularity of the pins an equivalent strain at the base of the annular grooves was obtained. Preliminary strain measurements of this kind were made to determine the longitudinal stresses at the surface of the piston rod due to tightening the six bolts fixing the side plates to the rod. A tensile force of 120,000 lb was then applied to the piston rod and the measurements were repeated.

Stresses in the piston rod at the base of the annular grooves were determined for two different designs of annular-groove systems and these designs as well as test results for both are shown in Fig. 20. The bolts were drawn equally tight for the test on each design. The stresses in the bolts were determined by measuring the change in length of each bolt with 0.0001-in. dial gages. Consideration of the factors of magnitude and uniformity of stresses in Fig. 20 leads to the selection of the second design, which is the one that was adopted for actual service applications with slight modifications. The stresses given are average stresses at the surface of the piston rod based on a gage length of $1^3/_8$ in. and the local stresses adjoining the fillets at the base of the annular grooves would be higher than the stresses shown. These fillet stresses, however, are calculated to be well within the endurance limit of the steel.

For locomotive applications, the system of annular rings is



STRESS IN P.S.I. AT BOTTOM OF VARIOUS ANNULAR GROOVES IN PISTON ROD DUE TO 120000 LBS PULL ON PISTON ROD & TIGHTENING OF 6 BODY BOLTS

		DESIGN 1			DESIGN 2		
GAUGE POSITION		1	4	1-4	1	4	1-4
STRESS DUE TO	TIGHTENING 6 BOLTS	ZERO	1,300	12,000	-9,500	-12,000	1,000
	120000 LBS PULL	4,300	-3,700	8,800	19,000	17,000	13,000
TOTAL STRESS		4,300	-2,400	20,800	9,500	5,000	14,000
GAUGE POSITION		2	5	2-5	2	5	2-5
STRESS DUE TO	TIGHTENING 6 BOLTS	8,000	5,500	4,500	15,000	22,000	12,000
	120000 LBS PULL	2,600	20,500	4,500	4,000	4,000	9,000
TOTAL STRESS		10,600	26,000	9,000	19,000	26,000	21,000
GAUGE POSITION		3	6	3-6	3	6	3-6
STRESS DUE TO	TIGHTENING 6 BOLTS	44,000	19,000	2,100	13,000	14,000	-600
	120000 LBS PULL	1,000	26,000	4,900	2,500	2,500	5,600
TOTAL STRESS		45,000	45,000	7,000	15,500	16,500	5,000

GAUGES 1 2 & 3 LOCATED ALONG ONE CROSSHEAD JOINT
GAUGES 4 5 & 6 LOCATED ALONG OTHER CROSSHEAD JOINT
GAUGES 1-4, 2-5 & 3-6 LOCATED IN LINE 90 DEGREES TO CROSSHEAD JOINTS

Fig. 20 Total Stress in Piston Rod Due to Tightening Crosshead Bolts and to a Pull of 120,000 Lb

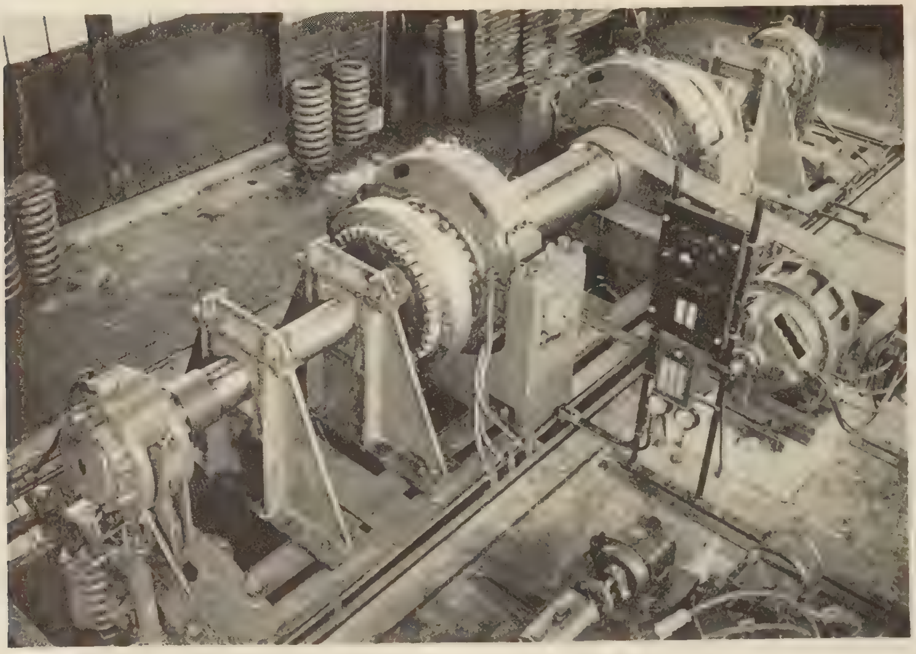


Fig. 21 Timken Axle-Fatigue-Testing Machine

(Two full-size $11^1/_2$-in. diameter driver axles are shown being tested, one at each end of the machine.)

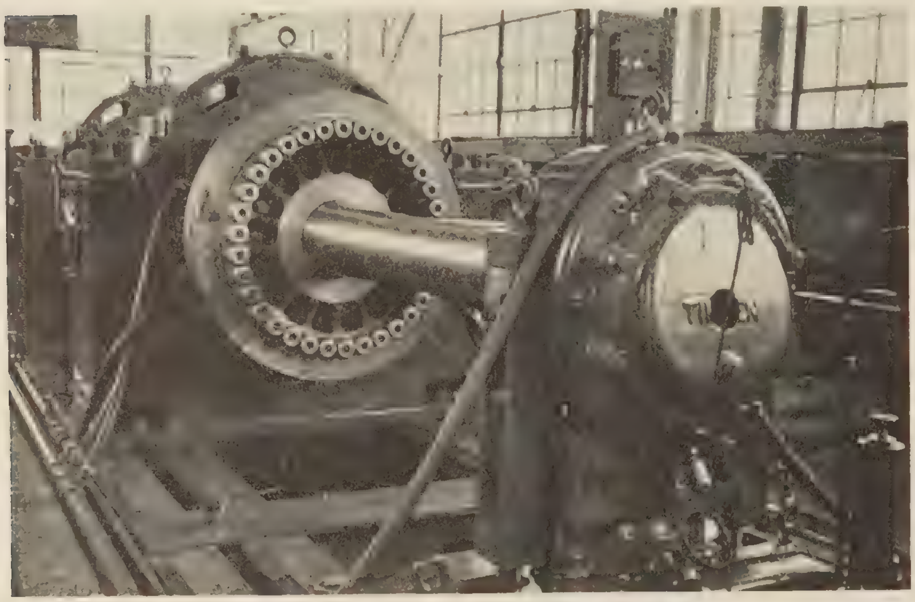


Fig. 22 One End of Timken Axle-Testing Machine Showing Arrangement of Axle During the Test

machined to close tolerances, using gages, and then the piston rod is lapped-in to the crosshead body. By this procedure the desired fit and magnitude and distribution of stresses in the crosshead assembly are obtained.

Axle Design

This part of the paper discusses (*a*) the fatigue strength of axle assemblies, particularly the weakening effect due to the press fit of the wheel on the axle, and means of correcting this weakness, and (*b*) the impact forces on axles at high speeds and also how the axle design may be modified to reduce such dynamic forces.

Fatigue Testing of Full-Size Axles. In order to investigate the fatigue strength of full-size axle assemblies up through 14 in. diameter, the Timken locomotive-axle testing machine[7] shown in Fig. 21 was placed in operation in the Timken research laboratory late in 1936. At the present time full-size outboard driver axles having a wheel-seat diameter of $11^1/_2$ in. are being tested in

[7] Built by Riehle Testing Machine Division of American Machine & Metals, Inc., under the direction of A. Sonntag, chief engineer.

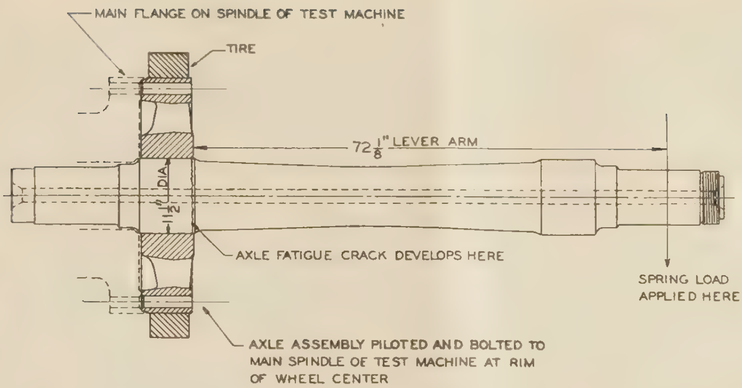


Fig. 23 Details of Axles Tested in Fatigue Machine

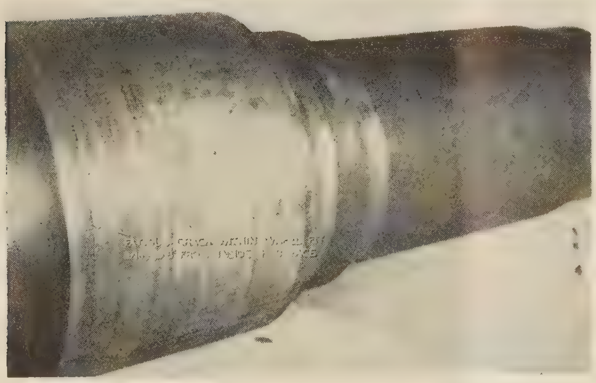


Fig. 24 Typical Fatigue Failure at Wheel Seat of $11^1/_2$-In. Diameter Full-Size Locomotive Driver Axle Developed in Timken Axle-Testing Machine

cooperation with the Pennsylvania Railroad. Fig. 22 shows a close-up view. Fig. 23 shows the details of this size axle now being tested. The operation and method of testing is self-explanatory from a study of Figs. 21, 22, and 23, but it may be added that two axles may be tested simultaneously, one at each end of the machine, loaded as cantilevers and at different bending stresses. The load is applied on the end of the axle by means of calibrated springs of long travel characteristics to give accuracy of load and reduce to negligible values the effects of any pulsating load due to eccentricities in the running of the axle.

Axle-fatigue failure develops within the wheel fit a short distance from the inside wheel hub face. This location is shown diagrammatically in Fig. 23. Fig. 24 shows a typical axle failure produced on the testing machine shown in Fig. 21. The general nature and location of this axle failure in Fig. 24, is comparable to that produced under service conditions.

At the time this paper was written, sufficient data had not been developed on the fatigue strength of full-size axles to justify even preliminary conclusions. When this paper is presented at the Detroit Meeting in May, additional data will be available. In the meantime, however, we may obtain some conclusion as to the low fatigue strength from the fact that the axle failure shown in Fig. 24 developed at a bending stress of 19,000 lb per sq in. after 5,730,000 rev. The material is a low-carbon 3.1 per cent nickel steel, normalized and tempered.

Scale-Model Tests on 2-In. Axles. As a forerunner to these full-size axle tests, several years experience are available (15, 16, 17) on the fatigue testing of 2-in. diameter scale-model axle assemblies. Approximately two-hundred 2-in. axles have been tested. Also other investigators (18, 19, 20) have studied this problem on $^5/_8$ in. and $1^5/_8$-in. diameter test axles. These tests on 2-in. axles are being continued parallel to the full-size tests so that a correlation may be made to determine the influence of size effect.

Considerable information is now available (15, 16) on these scale-model tests to conclusively show that the fatigue strength of 0.45 per cent plain carbon steel, normalized and tempered, is decreased from 34,000 lb per sq in. without a press-fitted wheel, to about 14,000 lb per sq in. with a press-fitted wheel or only 41 per cent of the strength available and that this greatly reduced strength is a result of high stress concentration introduced by the wheel fit. Several

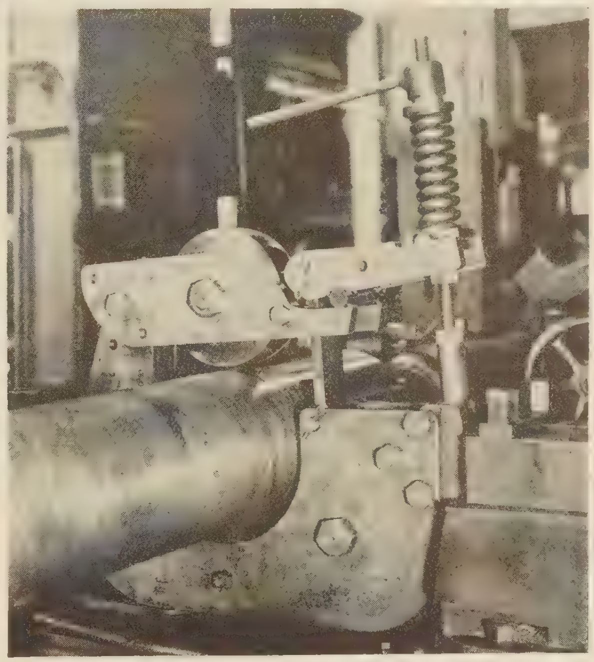


Fig. 25 Method of Surface Rolling 12-In. Diameter Driver Axles to Obtain Increased Fatigue Strength

(Spring pressure is applied through a calibrated spring and lever arrangement to three rollers spaced 120 deg apart which are mounted in a cradle supported on the traveling lathe carriage. Only the top roller is visible.)

means of improving this weakness have been developed and the most effective method is burnishing or cold rolling of the axle (17) in the region of the press-fitted members, as shown in Fig. 25. This rolling operation more than doubles the fatigue strength of the axle. Other methods such as relief grooves in the wheel hub face, raised axle seats at the wheel fit, and various steels and heat-treatments do not appear to give more than about 10 to 25 per cent increased strength for any one such method. Our schedule of tests includes the investigation of all these effects and others on both 2-in. and full-size axles. The stress concentration and weakening effect of axle fillets will also be investigated at a later date.

Impact Stresses in Axles. The usual empirical methods of determining axle design are based on using either (*a*) the static load plus allowance for vertical oscillations and low allowable design stresses, or (*b*) an axle loading similar to that in (*a*) in addi-

tion to large flange thrust, similar to the Reuleaux method which permits the use of higher allowable design stresses. Axles designed in this manner consider stresses determined by the axle diameter only as it affects the section modulus and do not express the dynamic stresses dependent upon the rigidity and unsprung weight of the axle assembly. Under conditions prevailing in present high-speed service, it becomes necessary to consider these additional factors in order to determine combined stresses which lead to axle failure.

The problem of weight requires no further explanation than to state that all unsprung parts should be made as light as possible. This discussion will then deal principally with the rigidity of the axle which may be simply defined as the resistance of the axle to deflection under a certain force. Any impact between the wheel and rail develops a certain energy, most of which must be absorbed in the unsprung-weight system. If we imagine the axle between the wheels as being a very elastic member, then much of this energy would be expended in deflecting the axle with resultant small impact forces in the axle compared to the case where a very rigid member connects the wheels.

In practice, the portion of the axle between the wheels is comparatively rigid and this is especially true with inboard axles where this portion is about the same diameter as wheel and bearing seats. This portion of the axle could be safely tapered to a much smaller diameter, which would result in lower axle impact stresses due to increasing the ability of the axle to deflect. This smaller diameter is further justified when one considers that (*a*) the bending moment gradually decreases between the bearing and wheel seats, and (*b*) a stress-concentration factor of at least two exists at wheel and roller-bearing seats due to the fitted members on the axle. This would mean that the center of the axle could have a diameter with a section modulus as small as one half of that at the wheel and bearing seats. As a specific example, an axle with 12-in. diameter wheel and bearing seats would be tapered to $9^1/_2$ in. diameter at the center, provided wheel gage may be maintained with axle under load.

What has been said previously, relative to inboard axles, also applies to outboard axles. We find, however, that outboard axles are already tapered to a smaller diameter at the center in the portion between the wheels. Very little test information is available to indicate just what axle proportions are best. A number of inboard- and outboard-type axles have failed in service at the wheel fit and the usual remedy has been to make the replacement axles not only larger at the wheel seat but also at the portion between the wheels. The usual empirical formulas applied to such designs would indicate lower calculated stresses at the wheel seat but they do not show the increased stresses due to the dynamical effect of greater weight and especially increased rigidity. When such axle failures develop it would appear to be better design to increase only the wheel-seat diameter and not to alter the portion between the wheels or in some cases even to make the center portion smaller in diameter.

It has already been reported on electric-locomotive lead-truck axles (3) that vertical accelerations on the unsprung journal box measured 7 to 13 times gravity, whereas on the main frame the acceleration was gravity. More data of this type would assist in making an intelligent analysis of this problem. From what has been said about the dynamical effects it is recommended that consideration be given to the study of modifying the present proportions of the ratios of axle, wheel- and bearing-seat diameters to the diameter of axle at the portion between the wheels.

Acknowledgment

The authors are indebted for the interest and cooperation of various railroads in connection with this work, which was conducted by the engineering staff of the railway division of The Timken Roller Bearing Company. The full-size axle tests are being developed in cooperation with the locomotive-design committee of the Pennsylvania Railroad. Beneficial discussions in connection with the paper were also had with Dr. S. Timoshenko, of Stanford University.

BIBLIOGRAPHY

1 "Stress Distribution in Aluminum Connecting Rods," by R. L. Templin, *Railway Mechanical Engineer*, vol. 109, March, 1935, p. 93.

2 "Die-Forged Locomotive Rods," *Iron Age*, February 4, 1937, pp. 67–71.

3 "Track Tests on Electric Locomotives," *Railway Age*, vol. 101, September 12 and 19, 1936, p. 374 and p. 412, respectively.

4 "Theory of Elastic Stability," by S. Timoshenko, McGraw-Hill Book Company, New York, N. Y., 1936, p. 137. Also: "Strength of Materials," by S. Timoshenko, D. Van Nostrand Company, Inc., New York, N. Y., 1930, vol. 2, p. 590. Also: "Westnik Ingenerow," by A. N. Dinnik, Moscow, 1916.

5 "Strength of Steel Columns," by H. B. Westergaard and W. R. Osgood, Trans. A.S.M.E., vol. 50, 1928, paper APM-50-9, pp. 65–80.

6 "Rational Design of Steel Columns," by D. H. Young, Proceedings, A.S.C.E., vol. 60, 1934, pp. 1421–1464.

7 "Theory of Elasticity," by S. Timoshenko, McGraw-Hill Book Company, New York, N. Y., 1934, p. 120.

8 "Über die Spannungsverteilung in Stangenköpfen," by J. Mathar, *Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 306, 1928.

9 "Das Augenstabproblem und Verwandte Aufgaben," by H. Reissner, Jahrb. Gesselschaft Luftfahrt, p. 126, 1928.

10 "Beitrag fur Berechnung der Spannungen in Augenstäben," by J. Beke, *Eisenbau*, vol. 12, 1921, p. 233 and p. 255.

11 "Photoelasticity," by E. G. Coker, *Journal of the Franklin Institute*, vol. 199, March, 1925, p. 289.

12 "Eye-Shaped End of Bar Investigated by Photoelastic Method," by K. Takemura and Y. Hosokawa, Aeronautical Research Institute, Tokyo Imperial University, Report No. 18, July, 1926, p. 127.

13 "Vorspannung und Dauerhaltbarkeit von Schraubenverbindungen," by A. Thum and F. Debus, *Mitteilungen der deutschen Materialprufungsanstalten an der Technischen Hochschule Darmstadt*, no. 7, 1936.

14 "The Mechanics of Plate Rotors for Turbo Generators," by J. P. Den Hartog, Trans. A.S.M.E., vol. 51, 1929, paper APM-51-1, pp. 1–12.

15 "Investigation of Fatigue Strength of Axles, Press Fits, Surface Rolling, and Effect of Size," by T. V. Buckwalter and O. J. Horger, presented at Annual Meeting of the American Society of Metals, 1936.

16 "Increasing the Fatigue Strength of Press-Fitted Assemblies by Surface Rolling," by O. J. Horger and J. L. Maulbetsch, *Journal of Applied Mechanics*, Trans. A.S.M.E., vol. 58, September, 1936, p. A-91.

17 "Effect of Surface Rolling on the Fatigue Strength of Steel," by O. J. Horger, *Journal of Applied Mechanics*, Trans. A.S.M.E., vol. 57, 1935, p. A-128.

18 "Der Einfluss von Oberflächenbeschädigungen auf die Biegungsschwingungfestigkeit," by W. Zander and K. Gunther, Veröffentlichungen des Wöhler-Instituts, Braunschweig, Nos. 1 and 2, N.E.M. Verlag, Berlin, 1928. Also, "Die Steigerung der Dauerhaltbarkeit durch Oberflächendrücken," by O. Föppl, *Maschinenbau*, vol. 8, 1929, p. 752.

19 "Der Einfluss von Einspann- und Kraftangriffstellen auf die Dauerhaltbarkeit der Konstruktionen," by A. Thum and F. Wunderlich, *Zeit. V.D.I.*, vol. 77, August 5, 1933, p. 851.

20 "Fatigue of Shafts at Fitted Members With a Related Photoelastic Analysis," by R. E. Peterson and A. M. Wahl, *Journal of Applied Mechanics*, Trans. A.S.M.E., vol. 57, 1935, p. A-1.

Oil-Film Thickness at Transition From Semifluid to Viscous Lubrication

By G. B. KARELITZ[1] and J. N. KENYON,[2] NEW YORK, N. Y.

This paper describes tests in which flat-faced pieces of several bearing metals were mounted to ride on a small journal which was lubricated by means of an oil bath. The initial lines of contact gradually developed into grooves until viscous oil films formed between the rubbing surfaces and arrested further wear. The minimum thickness of these wedge-shaped oil films were computed from observations made with tin-base, lead-base, bearing-bronze, and leaded-copper bearing metals, each being tested under loads of 20, 40, and 60 lb per sq in., respectively. It is shown that the film thickness is substantially independent of the load for any one individual material, ranging from 0.00003 in. to 0.00006 in. Photomicrographs of the surface structures of the bronze and tin-base babbitt are shown, which permit measurement of the height of excrescences. These measurements compare favorably with the computed values of minimum oil-film thickness. The observations are correlated with those given by McKee (6),[3] obtained on the running in of small bearings. The effect of different oils on the running in of babbitt is also indicated.

It IS considered in the theory of lubrication that a transition from viscous to semifluid friction occurs in a bearing when the minimum oil-film thickness is equal to the combined height of protrusions on the rubbing surfaces. Under these conditions the protrusions come into contact and begin to increase the coefficient of friction in the bearing. The experiments described in this paper were made for the purpose of ascertaining the thickness of the oil film when this transition takes place. It was reasonable to assume that the film thickness would vary for different materials, but would be the same for any given pair of metals under different loadings, and with the same lubricant.

Experimental Setup

The apparatus for the tests was suggested by the work of Connelly (1) and is shown in Figs. 1 and 2. It consists of a test shaft mounted on two ball bearings and connected with a small d-c electric motor. The shaft has a cantilever extension of $^5/_8$ in. diameter rotating in an oil bath which is maintained approximately at a level with the shaft center. The oil reservoir, shown in Fig. 2 replenishes the oil lost by leakage through the ball bearing adjacent to the bath.

A $1 \times 1 \times {}^1/_2$-in. bearing-metal test block is mounted on the loading lever and is held in place with a wing nut. The block rests on the test shaft as shown in Fig. 2. The loading lever is fulcrumed on a ball-bearing hinge and loaded at the other end by weights carried on a rather flexible spring. The lever ratio is 5:1. The dead weight of this loading arrangement is adjusted to give a 5-lb load on the test journal.

When the shaft rotates, oil is carried up and lubricates copiously the rubbing surfaces of the block and journal. A 0.0001-in. dial gage is mounted on a rigid arm so that its plunger may be brought in contact with the loading lever. This dial indicates the gradual sinking of the lever as the test block wears away by friction; it also gives an indication of the vibrational effect due to inaccuracy of the test shaft.

A thermometer is used to measure the temperature of the oil bath. An ammeter in the motor line shows the variation in the frictional torque on the shaft. Due to high losses in the small driving motor, the ammeter readings have only a relative value.

Test Procedure and Estimate of Film Thickness

The test blocks were machined to a good flat surface. The mounting was so arranged that four grooves could be obtained on each block, for different loadings. The initial reading of the dial gage was recorded at the start of the test. The readings changed rapidly during the first few minutes of the test, due to the rapid wearing away of the specimen. As the test proceeded, the area of contact widened and the rate of sinking decreased, reaching a nearly zero value at the end of 36 hr. The dial gage was employed to determine when this constant state had been reached. A variation in the dial gage reading of 0.0001 in. was equivalent to 0.00002 in. sinking of the test blocks. The total variation in the reading of the gage had a limited significance, since its initial reading depended on the depth of machine-tool marks on the surface of the blocks.

When the steady state was reached, a liquid film of oil obviously separated the rubbing surfaces. The minimum thickness of this film was just sufficient to separate the irregularities on the block from those of the shaft. The width of the groove worn in the block was such that the hydrostatic pressure created

[1] Associate Professor, Department of Mechanical Engineering, Columbia University. Mem. A.S.M.E. Mr. Karelitz was born in Russia in 1895 and received degrees in naval architecture and mechanical engineering from the Imperial Polytechnic Institute at Petrograd in 1918. For three years he was special engineer with the Waterways of Communication in Russia. He came to the United States in 1922 and has since been connected with the Westinghouse Electric & Manufacturing Company in the capacities of research engineer, manager of the mechanics division of the Pittsburgh research laboratories, manager of the transportation division of the South Philadelphia Works engineering department, and consulting engineer. He began his work at Columbia University in 1930.

[2] Instructor in Civil Engineering, Columbia University. Mr. Kenyon holds the degrees of A.B. from Syracuse University and B.S. and Met.E. from Columbia University. In 1916 he had charge of inspection of munition steel with the British War Mission. In 1918 he entered the employ of the Carnegie Steel Company in the manufacture of electric-furnace steel. In 1923 he was employed by Columbia University as testing engineer and has recently been appointed instructor in civil engineering. Mr. Kenyon is a member of the British Institute of Metals, the American Society for Testing Materials and the Electrochemical Society. He is a licensed professional engineer in New York State. He is the author of several technical treatises published by the A.S.T.M.

[3] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Special Research Committee on Lubrication for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until June 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

in the clearance between the surface of the groove and that of the shaft balanced the load on the block. The clearance was naturally wedge-shaped, as shown in Fig. 3.

The width a of the grooves worn in the test blocks varied from 0.020 in. to 0.060 in., depending on conditions. The corresponding values of angle θ were 3.7 deg to 10.9 deg. The formulas available for the load-carrying capacity of films between

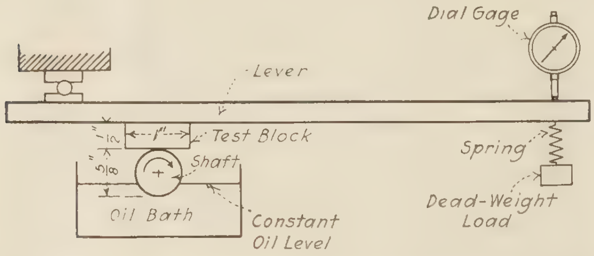


Fig. 1 Sketch of Testing Machine

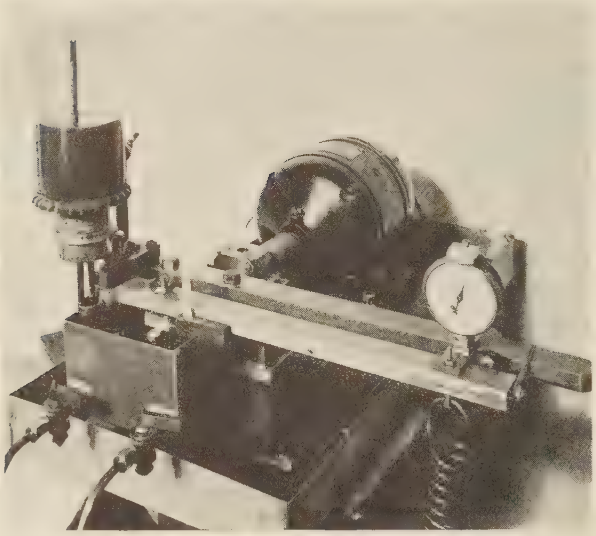


Fig. 2 The Testing Machine

flat surfaces should therefore apply with good accuracy to the films in the groove. The ratio of length to width was so large that the effect of side leakage could be neglected. Boswall (2) gives for the load-carrying capacity of a flat film

$$W = D \times \frac{6\mu\, U\, a^2\, L}{h_o^2} \qquad [1]$$

where W is the total load, lb; U is the peripheral velocity of the journal, in. per sec; a, as shown in Fig. 3, is the groove width, in.; L is its length, in.; h_o is the minimum film thickness, in.; μ is the absolute viscosity of the oil, lb-sec per in.^{2}; and D is a coefficient depending on the angle between the surfaces, i.e., on the ratio h_e/h_o (Fig. 3). According to Boswall the values of D are as follows:

h_e/h_o =	1.7	2.0	2.5	3.0
D =	0.0246	0.0265	0.0263	0.0246

The value of D varies but little for this range of h_e/h_o, the practical values of h_e/h_o being probably within the range. The value of $D = 0.026$ was therefore taken to hold for all test conditions. The viscosity $\mu = (1.45 \times 10^{-7})Z$, where Z is the viscosity in centipoises; $U = [\pi \times (^5/_8) \times (N/60)]$ in. per sec, where N is the speed of the motor, rpm. These values may be substituted into Equation [1], so that

$$h_e = 0.0000272 \sqrt{\frac{Z\, N\, L}{W}} \times a \qquad [2]$$

Equation [2] is good only for the journal of $^5/_8$ in. diameter.

The width a of the groove was measured with a micrometer microscope after removal of the test block from the machine. The width a was taken as the arithmetic mean of five values measured at equidistant points along the groove. The width a varied somewhat, largely due to slight inaccuracies in machining the flat faces on the test blocks.

Materials Tested

The shaft was of chrome-nickel steel of the following analysis: Carbon, 0.26 per cent; manganese, 0.74 per cent; phosphorus, 0.011 per cent; sulphur, 0.027 per cent; silicon, 0.14 per cent; chrome, 0.91 per cent; and nickel, 0.29 per cent. It had a good shop finish. No efforts were made to give it a high polish. During the numerous preliminary runs, however, the surface of the shaft became rather smooth. The accuracy of turning was satisfactory; the vibration at the end of the loading lever was found

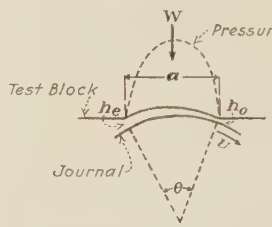


Fig. 3 Form of Oil Film Between the Journal and the Test Block

to be from 0.0006 in. to 0.0008 in., corresponding to only from 0.0001 in. to 0.0002 in. out of true on the test journal (5:1 ratio).

After several preliminary runs, test blocks were prepared of four typical bearing alloys, as shown in Table 1. The molds were built up of steel plates, and the metal was cast into cavities of $1 \times 1 \times ^1/_2$ in. The photomicrographs of the samples showed that the castings were overchilled.

TABLE 1 BEARING MATERIALS USED

Alloy no.	1	2	3	4
Material	Tin-base babbitt[a]	Lead-base babbitt	Bearing bronze	Leaded copper
Composition, per cent	Sn 89.0 Sb 7.5 Cu 3.5	Pb 85.0 Sb 10.0 Sn 5.0	Cu 80.0 Sn 8.0 P 12.0	Cu 70.0 Pb 30.0 .. ..
Pouring temperature, F	750	710	2000	1935
Brinell hardness at 82 F	22.3	17.1	71.0	30.0

Mold temperature approximately 200 F

[a] Exact analysis: Sn, 89.9 per cent; Sb, 7.3 per cent; Cu, 3.7 per cent

S.A.E. 30 oil, with the following viscosities, was used in the tests

Temperature F	80.5	100	120	160	210
Saybolt viscosity, sec	909	483	273	117.2	63.4
	779	424	252	109.7	61.1

The points fall on a straight line in the A.S.T.M. viscosity-temperature chart, which was used for finding the viscosities at running temperatures. The specific gravity of the oil was found to be

Temperature, F	60	85	120	180
Specific gravity	0.8775	0.8745	0.8705	0.8625

The temperature of the test block was measured with a thermocouple during the preliminary runs, and found to be 2 deg higher than the temperature of the oil in the bath. It was assumed that the average temperature of the oil in the oil film was 3 deg higher than the oil-bath temperature.

After each run the oil was changed, and the bath and shaft carefully cleaned, in order to eliminate the effect of bearing material ground off during the previous run.

TABLE 2 MINIMUM FILM THICKNESS h_o

Material	Load, lb	Oil-bath, temperature, F	Absolute viscosity Z oil film, centipoises	Speed N, rpm	Length of groove L, in.	Width of groove a, in.	Computed value of h_o, in.
1 Tin-base babbitt.......	20	119	50.5	2050	0.995	0.0254	0.000050
	40	118	49.6	2025	0.995	0.0346	0.000047
	60	122	44.4	2000	0.995	0.0431	0.000045
2 Lead-base babbitt......	20	120	47.0	2050	1.000	0.0301	0.000057
	40	119	50.5	2060	0.876	0.0447	0.000058
	60	125	41.8	2070	1.000	0.0572	0.000059
3 Bearing bronze.........	20	120	47.0	2010	0.885	0.0210	0.000038
	40	137	26.9	(2100)[a]	0.885	0.0338	0.000033
	60	133	30.4	2070	0.998	0.0398	0.000035
4 Leaded copper.........	20	101	66.3	(2140)	0.980	0.0228	0.000052
	40	104	61.8	2010	0.980	0.0302	0.000047
	60	105	60.2	2100	0.990	0.0327	0.000040

[a] Speed estimated, in absence of readings, at end of text.

Test Results and Values of h_o

As mentioned previously, the duration of each test was about 48 hr; the test blocks stopped sinking at the end of 36 hr after a viscous oil film had been established between the journal and test block. Typical curves of block sinking plotted against time are shown in Fig. 4. The corresponding temperatures of the oil bath and ammeter readings are also shown in Fig. 4. Each block was tested under loads of 20, 40, and 60 lb, a separate groove being worn in the surface for each load. This eliminated the probable structure variation in different test blocks of the same material.

The observations of the test results together with the computed values of the minimum film thickness h_o are given in Table 2.

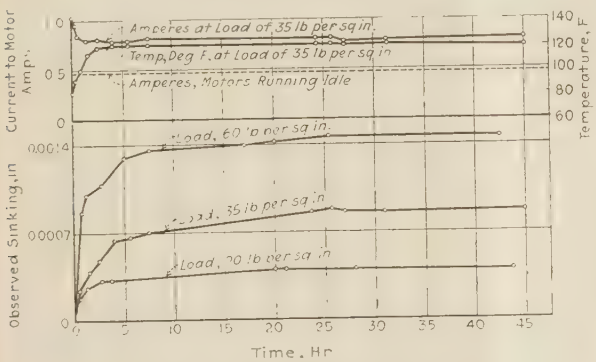


Fig. 4 Rate of Block Sinking, Power Requirements, and Oil Temperatures

It seems that, within the limits of experimental error, the film thickness h_o did not change for any one metal, irrespective of the load on the bearing block. However, the values of h_o did change from metal to metal. The scattered results obtained with the lead-copper alloy were probably caused by the nonuniformity of the material in the specimen, this alloy being rather difficult to cast.

As a matter of record, and to indicate how far values of h_o may vary for different blocks of the same chemical composition, the observations made during the preliminary runs with the various metals are given in Table 3. The oil used was the same as for the test runs. The babbitts show a good correlation between the preliminary runs and the regular tests. The bronze samples show a wider divergence, particularly the leaded copper. It should be remembered that castings of the latter metal, which have been poured at different times, may vary considerably in structure.

TABLE 3 VARIATIONS IN h_o FOR DIFFERENT BLOCKS OF SAME CHEMICAL COMPOSITION

Metal	Load, lb	Temperature of bath, F	Computed value of h_o, in.
Tin-base babbitt........................	35	127	0.000052
Tin-base babbitt, + 4 per cent lead.......	35	127	0.000048
Lead-base babbitt......................	35	129	0.000058
Bearing bronze.........................	35	131	0.000060
	35	129	0.000050
	60	129	0.000043
	20	123	0.000045
Leaded copper..........................	35	124	0.000040
	60	137	0.000037

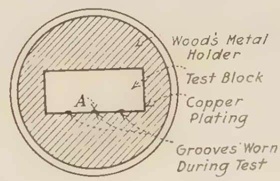


Fig. 5 Method of Mounting the Test Pieces for Polishing

Contact Surface of Bearing Metal

The hydrodynamic theory of lubrication maintains that the bearing metal should wear until the state is reached when the film thickness is equal to the combined height of protrusions on the rubbing surfaces. Therefore, photomicrographs were taken of the cross sections of the bearing blocks near the rubbing surface. The purpose was to observe the actual height of the protrusions and compare these with the computed values of h_o, but to achieve this a magnification was required beyond the power of ordinary microscopes. Fortunately, the assistance of the Bell Telephone Laboratories could be secured, and F. F. Lucas and R. M. Sample were willing to prepare and examine the surface structure of the sections of the test blocks, using the instrument which was described briefly in *Mechanical Engineering* (3).

The polishing of a sample for study under a microscope presents particular difficulties if the structure at the cross-sectional edge is in question. This is due to the fact that even with most careful polishing the edges are rounded off. The focusing of the microscope on the edge is thus interfered with. In this case, the samples were copper plated in order to protect their surfaces, then mounted in Wood's metal for convenience of handling, and the cross section of the sample was carefully polished. The mounting is shown in Fig. 5. Even with these precautions, the polished surface could be obtained reasonably flat at the edge only when the material of the test piece was approximately of the hardness of the copper plating; the surface was slightly rounded, however, with materials appreciably softer than the copper plating. Therefore, it was possible to obtain good photographs of the bearing-bronze test piece; however, the babbitt test pieces were rounded off. The copper-plating

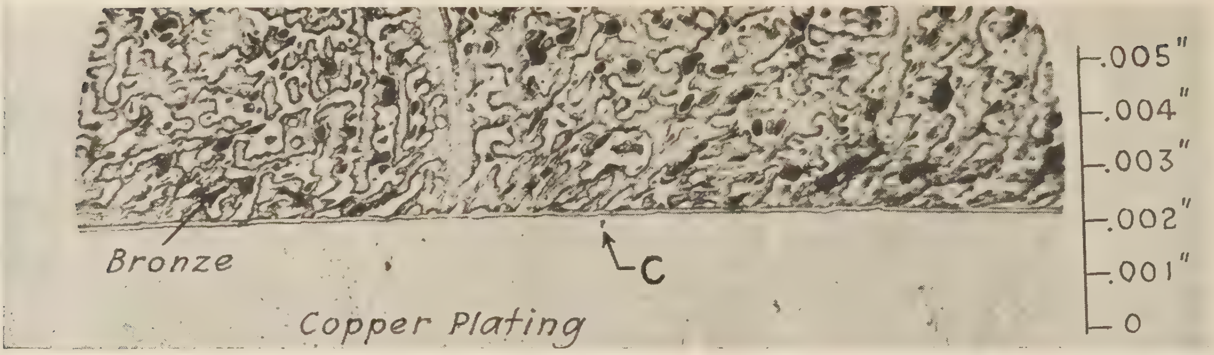


Fig. 6 Surface Structure of Bronze Test Piece, ×300

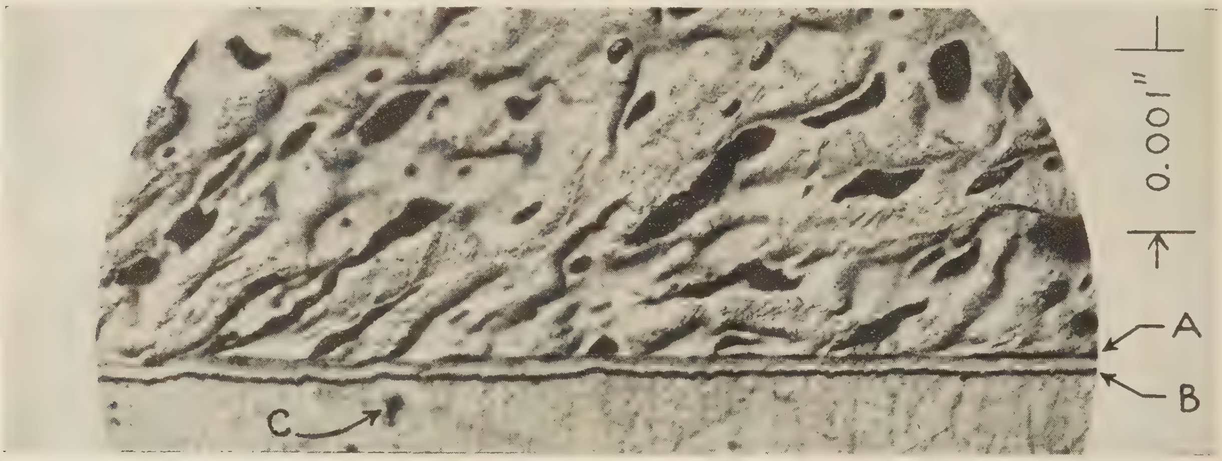


Fig. 7 Surface Structure of Bronze Test Piece, ×1000

could probably be replaced by a softer protective coat, but further work on the subject was not warranted at the time.

Figs. 6, 7, and 8 show the cross section of the bronze test block at the surface of a groove, that is, at point A shown in Fig. 5. The respective magnifications of the three original photographs were 300, 1000, and 4000 diameters. The film-like appearance of the plating at the surface of the bronze was due to the employed technique of copper plating: approximately 0.0001 in. was put on with extreme care, the process of plating was then speeded up. The sharp line B in Fig. 7 is merely the line of demarcation of the two copper platings, while line A is the trace of the bearing surface, of interest for this investigation.

The pinhole C in the copper plating was used for identification of location in the Figs. 6, 7, and 8, so that the structure of the bronze at the bearing surface may be studied conveniently under the three magnifications. Fig. 8 permits direct measurement of the unevenness of the bearing surface. The height of excrescences was found to be 0.000043 in., which compares well with the computed value of h_o = 0.000035 in. for the bronze test piece. Of course, the height of the excrescences on the surface of the steel journal was not known.

Unfortunately, the babbitt test pieces could not be investigated with the same positiveness; and data for comparison of measured height of unevenness with computed values of h_o could not be obtained for the four different materials. Fig. 9 shows the cross section of the test block of tin-base babbitt at the surface. The magnification is the same as in Fig. 8, that is, 4000 diameters. The excrescences seem to be of the same order as in the bronze. It may be noticed that the lens was focused on the edge of the cross section, the surface further inward being out of focus. This was due to the mentioned rounding of the test piece during polishing.

Mechanism of Running In the Bearings

Figs. 6, 7, and 8 give an insight into the mechanism of running in. At the beginning of the experiment, the metal of the test block was subjected to an excessive pressure, much higher than those existing in actual bearings. However, after the test had progressed 2 or 3 hr the pressures on the working surface of the grooves were comparable to those in heavily loaded bearings. At the end of the test the pressures ranged under various conditions from 600 to 1500 lb per sq in. Taking into consideration that in ordinary bearings, while they are run in, the load is carried to a large extent by the high spots of the bearing surface, the unit pressure upon these high spots must be rather great. It may well be assumed that the phenomena at these spots resemble closely the wearing in of the test blocks in the experiments described here.

Figs. 6, 7, and 8 show distinctly that the crystals of the bearing metal were mechanically distorted by the action of the shaft. The drag effect upon the metal was rather uniform over the whole surface of the groove, penetrating to a depth of approximately 0.0015 in. No cracks were apparent; the crystals flowed into their oblique position rather than being crushed into it. In addition to the smearing action, the shaft ground off the surface crystals; the combination of the working and abrasion gave the mirror-like finish characteristic of a run in surface of a bearing.

Fig. 9 reveals a different situation in the case of tin-base bab-

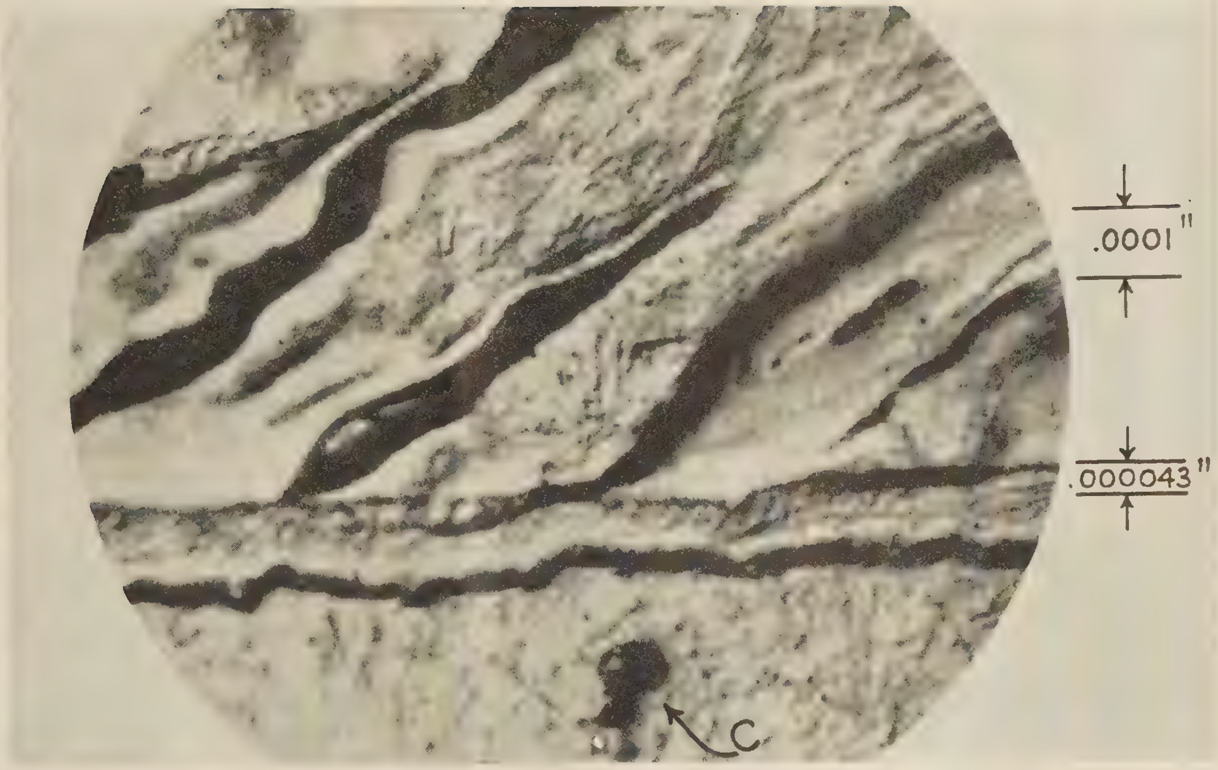


Fig. 8 Surface Structure of Bronze Test Piece, ×4000

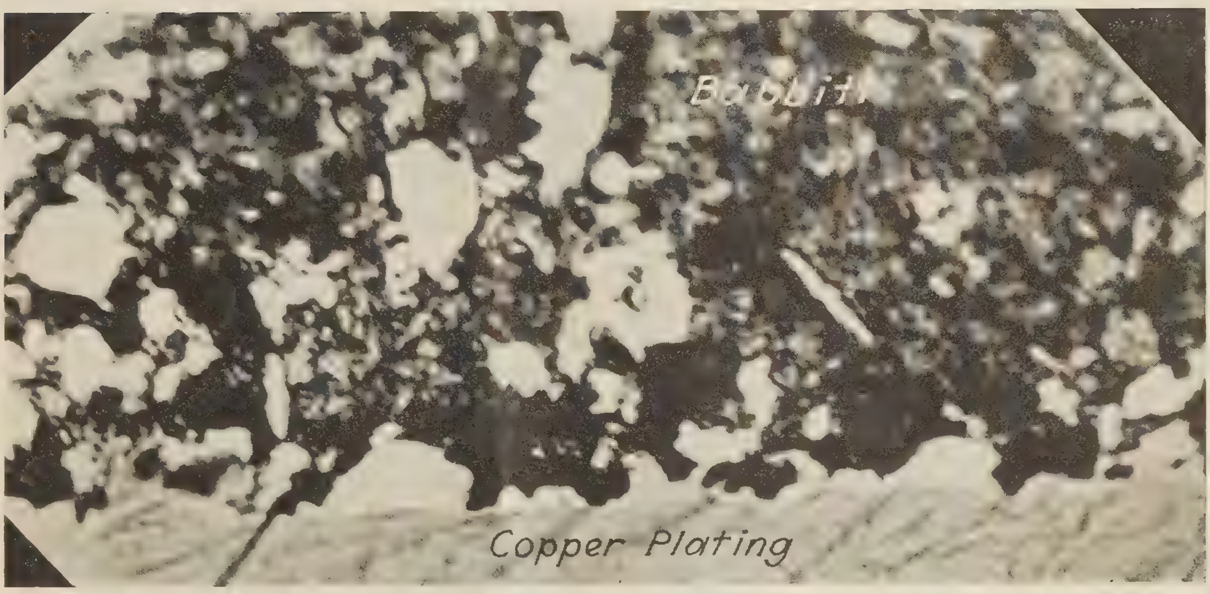


Fig. 9 Surface Structure of Tin-Base Babbitt Test Piece, ×4000

bitt. This might be expected, in view of the radically different constitution of babbitts and bronzes. A tin-base babbitt consists of an eutectic matrix into which crystals of tin-antimony and copper-antimony are imbedded. The crystals apparently give the metal its strength. At elevated temperatures the eutectic becomes comparatively soft and flows easily, thus being responsible for the loss of Brinell hardness. The eutectic becomes mushy at a temperature approaching 310 F when the babbitt may be wiped in the bearing (4). Accordingly, instead of distortion and abrasion of the metal, as was the case with bearing bronze, Fig. 9 shows the eutectic worn away, and the hard white crystals of tin-antimony left behind, providing a pavement on the surface of the babbitt. The crystals are partly crushed and partly abraded. Fig. 9 does not permit measuring the uneven-

TABLE 4 MINIMUM OIL-FILM THICKNESS AS DETERMINED FROM TWO SERIES OF TESTS BY McKEE

	First series[a]			Second series[b]		
Number of run	1	5	10	1	4	8
McKee's (6) values of ZN/P	36.0	19.5	11.5	26.5	9.0	5.0
Dennison's (7) values of m	11.6	20.0	40.5	2.0	3.6	4.6
$h_o = (1/m)\ (\delta/2)$	0.000116	0.000068	0.000033	0.00014	0.000078	0.000061
Corresponding eccentricity of bearings	0.913	0.950	0.975	0.500	0.730	0.780

[a] Using a set of bearings with a clearance ratio $\delta/D = 1/450$, and a radial clearance $\delta/2 = 0.00135$ in.
[b] Using a set of bearings with a clearance ratio $\delta/D = 1/2250$, and a radial clearance $\delta/2 = 0.00028$ in.

ness of the surface, but it may be judged to be of the same order as that of the bronze.

A sample of the lead-base babbitt was also prepared and examined. This material was still more difficult to polish than the tin-base babbitt, and satisfactory photographs could not be obtained. However, examination did show a mechanism of running in quite similar to the one in Fig. 9.

Bowden and Ridler (5) have found that under conditions of dry friction, as well as greasy friction, individual particles on the rubbing surfaces may be heated to extremely high temperatures. With surfaces of Wood's metal they measured temperatures up to the melting point of the metal, thus indicating that the microscopic protrusions actually were liquefied and carried away. With copper and copper alloys they observed temperatures up to 1000 C. This heating was distinctly a surface phenomenon, the bulk of the bearing not showing a noticeable temperature rise. This information, when applied to the tests described herein, explains the flowing of the bronze, as well as the melting of the eutectic matrix at the babbitt surface. The melting temperature of the tin-antimony crystals is about 470 F, i.e., considerably higher than that of the eutectic.

The described mechanism of running in may account for the fact that a thinner oil film was observed with bronze than with tin-base babbitt. It would lead also to the conclusion that lead-base babbitt wears in to a rougher surface than tin-base babbitt. It is also natural to expect that leaded bronze, consisting of a copper-lead alloy with globules of lead entrapped mechanically in the alloy, should wear to a surface not as smooth as the bearing bronze, as was actually observed. On the other hand, one would anticipate its surface to be not much rougher than with babbitts, since experience shows that the leaded bronzes perform as well as the babbitts in automobile bearings.

The running in characteristic of a bearing metal is significant because bearings lined with the smoother metal should be able to carry heavier loads on a viscous film, barring the effect of mechanical or temperature distortion. This means that with the same oil viscosity, radial clearance, and speed, the rougher bearing will enter the semifluid range of friction at a lighter load than the smoother bearing would. It must be remembered, of course, that the experiments reported here are not sufficient to compare definitely different bearing metals. Additional tests are needed in order to formulate a reliable basis for judging running in qualities of various bearing metals.

Comparison With Tests on Running In Bearings

The observed values of h_o can be conveniently compared with values derived from the experiments by McKee on the effect of running in small bearings (6). McKee measured the total friction torque in a set of four bearings carried in one frame, mounted on a common shaft of 1.25 in. diameter. Two series of tests were reported: The first was with a set of bearings of clearance ratio $\delta/D = 1/450$, while bearings with a ratio $\delta/D = 1/2250$ were used in the second series. All bearings were 1.25 in. long. The friction was measured at intervals, while the bearings were gradually run in. McKee stated: "The first five runs of the first test were completed with no running in between runs, the effect produced by each run, in itself being sufficient to show a change in the curve for the succeeding run. In connection with all subsequent runs, however, some running in was done between runs at a value of ZN/P below that at the point of minimum friction for the preceding run." The duration of each run was approximately 2 hr.

The ZN/P values at the points of minimum friction for the consecutive runs are given in McKee's paper (6). It may be assumed that these points of minimum friction, or more correctly, the points of minimum coefficient of friction, are the points where the viscous film in the bearing breaks down, i.e., when the first metal-to-metal contact occurs. This is the condition which existed in the films under the bearing blocks described in the present paper. The bearings used by McKee were of tin-base babbitt (Sn, 85; Cu, 7.5; Sb, 7.5); the shaft was made of high-carbon-tungsten tool steel. The film thickness in the bearings, after running in, should, therefore, compare with the values obtained with the tin-base babbitt block. The film thickness at the points of minimum friction in the bearings tested by McKee can be determined using the charts computed by Dennison (7) for the case of high eccentricity, i.e., low values of ZN/P. Dennison gives the film thickness as $h_o = (1/m) \times (\delta/2)$, where $(\delta/2)$ is the radial clearance. The values of h_o at the points of minimum friction for several consecutive runs are given in Table 4. The minimum film thickness obtained with the bearings well run in are of the same order as those obtained with the test block. The latter fall between the values h_o computed for the two sets of McKee's bearings.

Effect of Lubricant on the Running In

In order to observe whether physical properties of the lubricant play an appreciable part in the mechanism of running in, a light commercial-stock oil was obtained from a source different from the oil used in the tests reported in this paper. In the following, this light oil will be denoted by letter B, while the oil which was used earlier will be called oil A. The viscosity of the oil B was

Temperature, F	100	210
Saybolt viscosity, sec	68.0	36.6

while its specific gravity was found to be

Temperature, F	60	75	120	180
Specific gravity	0.8759	0.8699	0.8593	0.8351

Another sample of oil B was received mixed with 1 per cent of butyl stearate by volume, an ingredient improving the oiliness of a lubricant.

Two bearing blocks, one of tin-base, the other of lead-base babbitt were used for this test. Babbitt blocks were chosen because their structure was more uniform across the bearing face than that of the bronze blocks. Each block was run with a load of 40 lb. One groove each was obtained with oil A, oil B, and alloyed oil B. The temperatures and corresponding viscosities of the oils are listed in Table 5. The shaft and the test pieces were cleaned carefully with carbon tetrachloride after each run. It was found that the lighter oil produced a decidedly thinner oil film (smaller value of h_o). This would indicate that the lighter oil created a finer polish on the surface of the groove. It should be noted that the 1 per cent butyl stearate apparently did not affect the performance, which was rather unexpected.

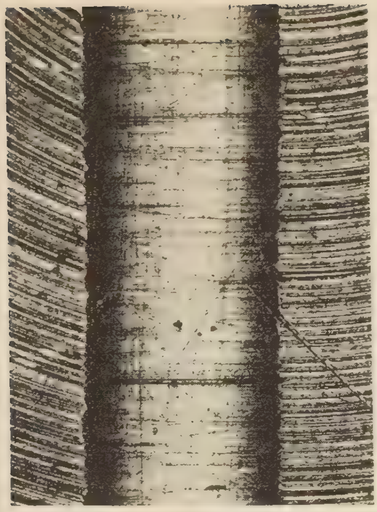


Fig. 10 Grooves Worn in Tin-Base Babbitt Using Plain Oil B, $\times 20$

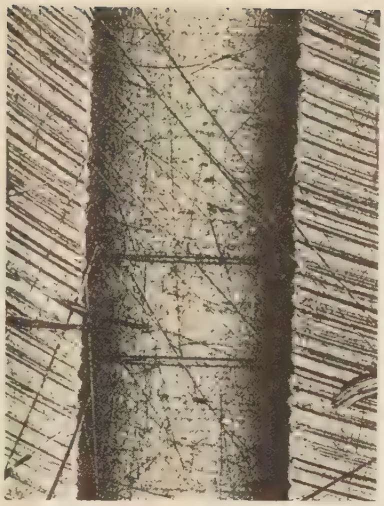


Fig. 11 Grooves Worn in Lead-Base Babbitt Using Plain Oil B, $\times 20$

Fig. 12 Grooves Worn in Tin-Base Babbitt Using Alloyed Oil B, $\times 20$

Fig. 13 Grooves Worn in Lead-Base Babbitt Using Alloyed Oil B, $\times 20$

Fig. 14 Grooves Worn in Tin-Base Babbitt Using Cold Oil A, $\times 20$

Fig. 15 Grooves Worn in Lead-Base Babbitt Using Cold Oil A, $\times 20$

Fig. 16 Grooves Worn in Tin-Base Babbitt Using Heated Oil A, $\times 20$

Fig. 17 Grooves Worn in Lead-Base Babbitt Using Heated Oil A, $\times 20$

TABLE 5 TEMPERATURES AND CORRESPONDING VISCOSITIES OBTAINED WITH OILS *A* AND *B*

Babbitt	Oil	Oil-bath temperature, F	Viscosity of oil film Z, centipoises	Width of groove a, in.	Minimum film thickness h_o, in.	Figure showing groove
Tin-base	B,	89	12.7	0.0541	0.000038	10
Lead-base	plain	90	12.2	0.0576	0.000041	11
Tin-base	B,	85	14.1	0.0591	0.000043	12
Lead-base	alloyed	86	14.0	0.0622	0.000047	13
Tin-base	A,	97	76.0	0.0347	0.000057	14
Lead-base	cold	97	76.0	0.0370	0.000057	15
Tin-base	A,	179	12.6	0.0884	0.000060	16
Lead-base	heated	182	11.9	0.0912	0.000066	17

The results obtained with the two different babbitts were in satisfactory agreement with each other

The viscosity of the oils being so different, it was possible that the comparatively rough surface obtained with the heavier oil, was caused by debris worn away from the block and carried in the more viscous lubricant. Therefore, an additional test was run with each block, using the oil A, but heating the oil bath by means of an electric element. As shown in Table 5, the viscosity of the lubricant was even smaller than that of the oil B. However, the minimum film thickness changed but slightly.

Illustrations of the eight grooves worn in the two blocks with the different oils are shown in Figs. 10 to 17, inclusive. All the illustrations were made under the same magnification of 20 diameters. Figs. 14 and 15 show clearly the pitmarks produced at the entering edge by the particles worn away and floating in the oil bath. It may be noticed that the groove is smooth at the trailing edge, indicating that the clearance between the shaft and bearing was too small for the particles to pass and was acting as a local filter for the oil. All other grooves, obtained with the oils of lower viscosity, were free from pitting.

Conclusion

The number of tests made with the machine was too small for generalizations, or to permit a definite comparison between the various bearing materials. However, the correlation of the obtained results with those derived from the experiments of McKee (6) is satisfactory. The several observations on individual materials were also rather consistent. The photomicrographs of the bearing cross sections at the rubbing surface showed excrescences comparable with the observed minimum film thickness, under conditions analogous to those existing in bearings at the point of transition from viscous to semifluid lubrication. Therefore, it was deemed that the information might be of value to engineers interested in the performance of bearings or in their lubrication. The authors take this opportunity to express their appreciation of the helpful cooperation obtained from F. F. Lucas and R. M. Sample of the Bell Telephone Laboratories.

Bibliography

1 "A New Method of Investigating Performances of Bearing Metals," by J. R. Connelly, Trans. A.S.M.E., vol. 57, 1935, paper IS-57-1, pp. 35–39.

2 "Theory of Film Lubrication," by R. O. Boswall, Longmans, Green, and Company, London and New York, 1928, chapter 3, p. 42.

3 "Magnifying 5000 Diameters," *Mechanical Engineering*, vol. 59, February, 1937, p. 113.

4 "A Study of Tin-Base Bearing Metals," by O. W. Ellis and G. B. Karelitz, Trans. A.S.M.E., vol. 50, 1930, paper MSP-50-11, pp. 13–28.

5 "Surface Temperature of Sliding Metals; the Temperature of Lubricated Surfaces," by F. P. Bowden and K. E. W. Ridler, Proceedings of the Royal Society of London, series A, vol. 154, 1936, pp. 640–656.

6 "Effect of Running In on Journal-Bearing Performance," by S. A. McKee, *Mechanical Engineering*, vol. 49, December, 1927, pp. 1335–1340.

7 "Film-Lubrication Theory and Engine-Bearing Design," by E. S. Dennison, Trans. A.S.M.E., vol. 58, 1936, paper OGP-58-1, pp. 25–36.

Operating-Cost Analysis of Electrified Oil Lines

By W. H. Stueve,[1] Oklahoma City, Okla.

The author submits data on the capacity and power requirements when pumping oil through two 10-in. pipe lines, 191.4 and 126 miles long, respectively. The first of these lines has three stations, located at approximate distances of 60 miles, each of which is equipped with plunger pumps handling 35,000 bbl of crude oil per day at a pressure of 800 lb per sq in. The second line has four stations, located at approximate distances of 32 miles, each of which is equipped with centrifugal pumps handling 40,000 bbl of crude oil at a pressure of 800 lb per sq in. The author gives the relative efficiencies of the centrifugal and plunger pumps and determines the overall pumping charges for each line. He calculates the operating costs if oil engines were installed as prime movers instead of electric motors. Calculations are also made to show the effect on operating charges if larger diameter pipe were installed, and if the pumping stations were spaced farther apart than in the existing lines.

The large volumes of crude oil offered to the market through the discovery of the Seminole field in Oklahoma and the West Texas and East Texas fields, caused widespread expansion of pipe-line facilities of the major pipe-line companies from 1926 to 1930. At the beginning of this expansion period it was common practice to use electric motors for small gathering pumps and oil engines in the larger main-line pumping stations. About 1927 the first motor-driven centrifugal oil-line pumps were considered for use in this industry. Today there are 200,000 hp of motor-driven pumps in this kind of service, representing approximately 20 per cent of the total installed horsepower for main-line pumping stations.

Before any data were obtainable relative to the performance of stations using electrically driven pumps, design engineers were prone to use theoretical values of pressures, viscosities, pump efficiencies and other factors which influence the cost of pumping oil. Today, after motor-driven centrifugal pumps have been in use for nearly 7 years, and motor-driven plunger pumps have been in use for nearly 5 years, information regarding the performance and power requirements of such units is meager and difficult to obtain, and when such meager information is available it is usually restricted to private use. However, reliable data of this nature have been obtained by the author from several pipe-line companies. These data show the average daily delivery in barrels per day for each month, and electric energy purchased per month at stations where oil is pumped through a 10-in. pipe line by plunger pumps driven by slow-speed induction motors, and at other stations where oil is pumped through a 10-in. pipe line with centrifugal pumps driven by relatively high-speed induction motors.

Therefore, the scope of this paper will be to determine the relative efficiencies of these centrifugal and plunger pumps, and to determine the overall pumping charges, considering the total investments in the several types of pumping stations. An effort will be made also to calculate the operating costs if oil engines were installed as prime movers instead of electric motors. Calculations will also be made to show the effect on operating charges for the entire pipe lines had larger diameter pipe been installed, and if pumping stations had been spaced farther apart than in the existing lines.

For the sake of simplicity, and to avoid disclosing the actual identity of the source of information, the pipe line equipped with plunger pumps will be known as Alpha Pipe-Line Company. This company utilizes three 600-hp stations, called A, B, and C, respectively, to pump about 35,000 bbl of crude oil per day at 800 lb per sq in. through a 10-in. pipe 191.4 miles long. The crude oil pumped has an average viscosity of about 50 S. sec U. and an A.P.I. gravity of 35 deg. There is a distance of 58.6 miles between stations A and B, 69.2 miles between stations B and C, and 63.6 miles between station C and the end of the line. The elevations of stations A, B, and C are 262, 343, and 103 ft, respectively. The line ends at an elevation of 52 ft.

The pipe line equipped with centrifugal pumps will be known as the Omega Pipe Line Company. This company utilizes four 800-hp stations, called W, X, Y, and Z, respectively, to pump 40,000 bbl of crude oil per day at 800 lb per sq in. through a 10-in. pipe 126 miles long. The crude oil pumped has an average viscosity of about 100 S. sec U. and an A.P.I. gravity of 30 deg. There is a distance of 29.5 miles between stations W and X, 29 miles between stations X and Y, 35 miles between stations Y and Z, and 32.5 miles between station Z and the end of the line. The elevation of stations W, X, Y, Z, and the end of the line are 915, 997, 1075, 1017, and 875 ft, respectively.

Comparison of Pump Efficiencies

Fig. 1 shows the average daily volume pumped, and the total electric energy in kilowatthours consumed each month by the three 600-hp plunger-pump stations A, B, and C of the Alpha Pipe-Line Company from October, 1931, to January, 1936.

Fig. 2 shows the average daily volume pumped, and the total electric energy in kilowatthours consumed each month by the four 800-hp centrifugal-pump stations W, X, Y, and Z of the Omega Pipe Line Company from January, 1929, to January, 1936.

From Figs. 1 and 2 may be noted the wide fluctuation in average daily deliveries from month to month during the years covered, and with particular significance the fluctuations in electric energy required are noted. In all cases when the most economical

[1] Commercial Department, Oklahoma Gas and Electric Company. Mr. Stueve was graduated from Ohio State University in 1909, with degrees of E.E. and M.E. During the War he served as engineer officer in the transport force with the rank of ensign and lieutenant (JG) in the United States Navy. For ten years he was a consulting engineer in Oklahoma for municipal power and water plants. In his present position he is in charge of electric-power sales to the petroleum industry for the Oklahoma Gas and Electric Company. Mr. Stueve was awarded the professional degree of mechanical engineer in 1936 by Ohio State University. He is a registered professional engineer in Oklahoma.

Contributed by the Petroleum Division and presented at the Semi-Annual Meeting of The American Society of Mechanical Engineers held at Dallas, Texas, June 15 to 20, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until June 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

use is made of electrical power, the energy consumed by all such stations, expressed in per cent of the total electrical energy required to pump at the maximum design rate, is equal to the capacity factor expressed in per cent of maximum capacity raised approximately to the 2.2 power, as developed later in Fig. 6.

This rule will follow when specific months are selected from Figs. 1 and 2. The rule will also follow approximately when the annual average deliveries are considered for years taken as a whole.

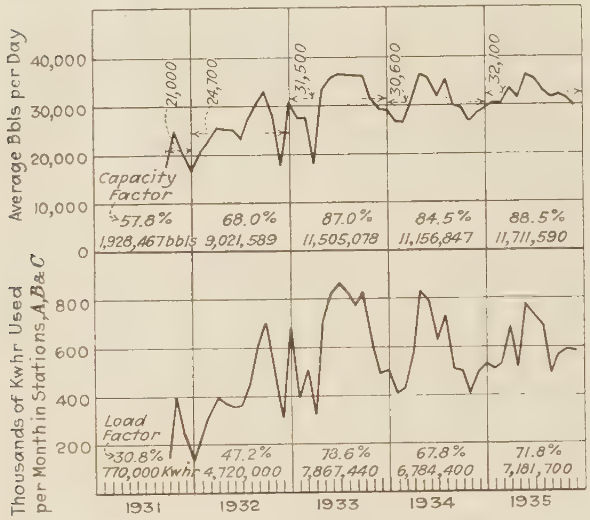


Fig. 1 Pumping Capacities and Energy Requirements of the Alpha Line

Table 1 is prepared from specific typical months to determine the pump efficiencies at various rates of pumping. The energy requirements listed in Table 1 are in kilowatthours per barrel pumped per 100 miles, in order to make the results comparable for both pipe lines, since the stations on the Alpha line are about 64 miles apart, while those on the Omega line are spaced about 32 miles apart.

The computed results shown in Table 1 for the Alpha pipe line equipped with duplex double-acting plunger-pump stations, indicate the very high average mechanical efficiency of 98 per cent for the pumps when operating at their designed maximum ratings using both plungers. In the case where 25,000 bbl were pumped per day, one of the duplex pumps was operated with one plunger disconnected from the crosshead, and the overall mechanical efficiency dropped to an average of 85 per cent for this condition. Again note that when only one pump was required as in January, 1932, pumping 17,500 bbl per day, its maximum capacity, against fairly high pressures, the mechanical efficiency again was of the order of 96 per cent, or that achieved when both pumps were operated at high design pressures. In this case station A pumped through stations B and C, that is, the entire length of the line or 191.4 miles.

In April, 1933, the same average volume of 17,500 bbl per day was pumped, but each of the three stations, A, B, and C was operated, building up pressures at each of the stations of only one third of the total pressures or perhaps 220 lb per sq in., and the mechanical efficiency dropped down to 55 per cent. This method of pumping is very uneconomical, since the kilowatt-hours per barrel per hundred miles was increased to 0.32, or approximately two and one half times the energy required had the pump of station A been permitted to pump the entire distance of 191.4 miles against the high design pressure of about 800 lb per sq in.

Referring to Fig. 3a, note that the points on the curve for kilowatthours per barrel per 100 miles for selected months very closely approximate the points for yearly averages of kilowatthours per barrel per 100 miles taken from Fig. 1, tending to lend considerable merit to the mechanical efficiency of plunger pumps as given in Table 1 for the Alpha line.

The computed results in Table 1 for the Omega pipe line equipped with centrifugal pumps, indicate that the pump efficiency when operating at a maximum capacity of 40,000 bbl per day is about 60 per cent, and that when the discharge is throttled for lower capacities the efficiency points are lower, as would be expected. In this line, two pump units are used in series until the capacity drops to about 70 per cent of the maximum, at which point the line pressure is only one half that of the line pressure required for 100 per cent capacity and, therefore, one pump unit will deliver the required pressure. Note, in Fig. 3b that when this condition prevails, namely, when the average daily pumping requirements are only 70 per cent of the maximum, or 40,000 bbl per day in this case, the efficiency of the single pump unit is 55 per cent, but no doubt the mechanical efficiency would be higher if the pipe line did not act as a throttle to the pump. This can readily be illustrated by extending the efficiency curve for the single pump unit in Fig. 3b to the point where 40,000 bbl would be pumped per day, at which point the single pump unit would show an efficiency of 68 per cent, the original factory guarantee.

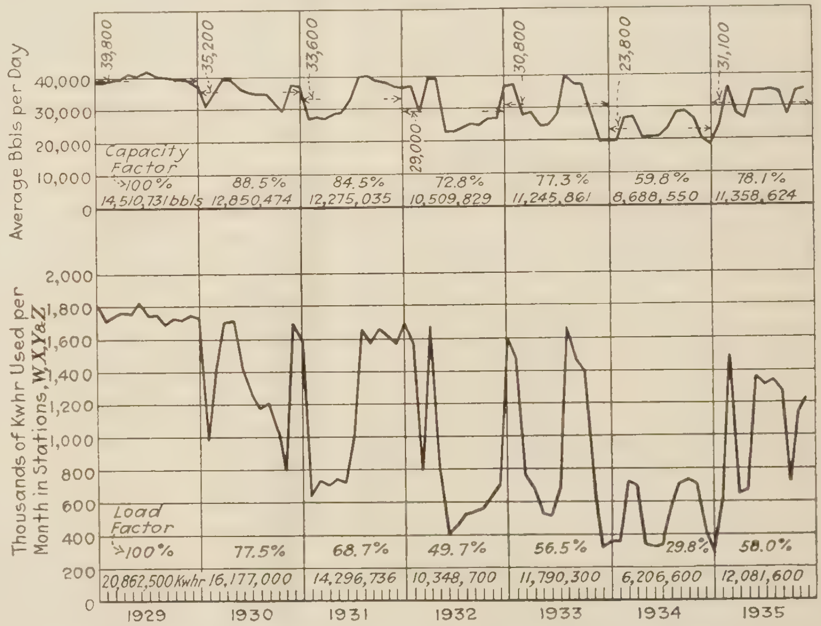


Fig. 2 Pumping Capacities and Energy Requirements of the Omega Line

Also, it may be said that the mechanical efficiencies of the centrifugal pump as derived from data given in Table 1 may not be exactly fair to the centrifugal pump, since the mechanical

TABLE 1 DETERMINATION OF PUMP EFFICIENCIES FROM FIGS. 1 AND 2 FOR SPECIFIC MONTHS

(a) Alpha pipe line[a] Time period selected	Average daily barrels pumped	Total kwhr consumed	Average fluid theoretical hp	Average total lb per sq in.	Average electrical input, hp	Overall efficiency, per cent	Guaranteed motor efficiency, per cent	Determined pump efficiency, per cent	Kwhr per bbl per 100 miles
July, 1933	36,150	865,000	1420	2325	1550	90	92	98	0.403
March, 1935	30,500	535,000	875	1725	960	90	92	98	0.296
May, 1932	25,000	370,000	506	1190	663	76	90	85	0.250
January, 1932[b]	17,500	135,000	196	655	243	81	85	96	0.131
April, 1933[c]	17,500	320,000	196	655	595	33	60	55	0.320
(b) Omega pipe line[d]									
October, 1929	40,000	1,740,000	1720	2520	3100	56	94	60	1.130
July, 1935	35,000	1,350,000	1200	2020	2420	50	94	53	0.990
February, 1930	31,000	1,000,000	865	1640	1970	44	93	48	0.920
March, 1931[e]	28,000	740,000	660	1380	1320	50	92	55	0.680
September, 1932	25,000	540,000	485	1130	1000	48	91	52	0.580
January, 1934[f]	20,000	360,000	260	760	640	41	90	45	0.460

[a] The 10-in. Alpha line is equipped with plunger pumps and is 191.4 miles long.
[b] Station *A* pumped to destination, a distance of 191.4 miles.
[c] Stations *A*, *B*, and *C* in operation.
[d] The 10-in. Omega line is equipped with centrifugal pumps and is 126 miles long.
[e] Pump driven by a 400-hp motor operated at stations *W*, *X*, *Y*, and *Z*.
[f] Pump driven by a 400-hp motor operated at stations *W* and *Y* only.

efficiency depends on knowing the fluid or theoretical horsepower, and this factor cannot be positively calculated from the data submitted unless more information on the actual pumping pressures, under all conditions of capacity, is made available at each of the stations. Again note from Fig. 3*b* that the points showing the annual average kilowatthours per barrel per 100 miles fall very close to the curve for kilowatthours per barrel per 100 miles for specific months, tending to lend considerable merit to the pump mechanical efficiencies given in Table 1 for centrifugal pumps in the Omega line.

After having determined the approximate energy required to pump given volumes of crude oil through several pipe lines, and having determined the mechanical efficiency of the two accepted types of plunger and centrifugal pumps, the author deemed it of importance to show the actual costs of operation, after taking

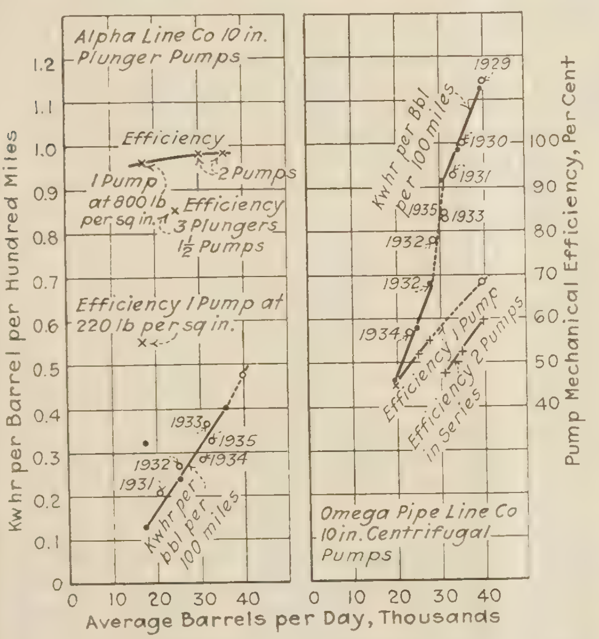


FIG. 3 GRAPHIC REPRESENTATION OF RESULTS LISTED IN TABLE 1

into account all charges, had the Omega line been equipped in 1928 with plunger pumps driven with 350-hp, 585-rpm induction motors.

COMPARISON OF PUMPING COSTS

Had the Omega pipe line been equipped with plunger pumps,

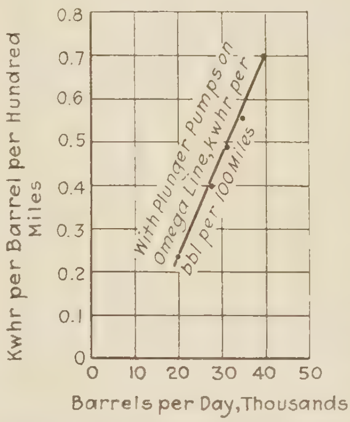


FIG. 4 ENERGY REQUIRED BY PLUNGER PUMPS OPERATING ON THE OMEGA LINE

the energy required by such pumps would be in inverse proportion to the respective determined overall (motor and pump) efficiencies given in Table 1 and shown graphically in Fig. 3. The mechanical efficiencies plotted in Fig. 3 are for both types of pumps but for different capacities, and are taken from actual data.

Fig. 4 shows the energy which would be required if the Omega line were equipped with plunger pumps, and pumping the same type of crude oil, that is, oil with a viscosity of 100 S. sec U. and an A.P.I. gravity of 30 deg.

In 1928 centrifugal pumps with speeds of 3600 rpm were not very well received by pump designers. Since that time performance and cost data on these pumps have become available, and the comparison of pumping costs outlined in this paper was selected because the author believes such a comparison will be of interest to design engineers and will enable them to make the proper selection of pumps at this time.

The pumping stations on the Omega line, equipped with three centrifugal pumps, each driven by a 400-hp motor running at 1760 rpm, have a capacity of 40,000 bbl per day. This capacity is delivered with two pumps in series at a pressure of about 800 lb per sq in. One 400-hp unit is for stand-by purposes. The total cost of each station was approximately $70,000.

If plunger-pump stations were installed on the Omega line, they would probably be equipped with three $5^1/_2 \times 24$-in. duplex double-acting pumps geared to 350-hp motors running at 585 rpm. Each of these pumps would be capable of delivering 20,000 bbl per day, or with two pumps in parallel, the capacity would be 40,000 barrels per day, this latter volume being the same as the capacity of the two centrifugal pumps in series. One 350-hp unit would be used for stand-by purposes. The total cost of such a station is estimated at $110,000.

Table 2 has been prepared to show the annual operating costs of plunger-pump stations on the Omega line. The theoretical costs were determined from Figs. 2 and 4. The cost per kilowatthour per barrel per 100 miles for pumping oil with plunger pumps was taken from Fig. 4, while the average annual volume

TABLE 2 ANNUAL OPERATING CHARGES FOR THE OMEGA PIPE LINE OVER A PERIOD OF 7 YEARS, AT THE ANNUAL AVERAGE RATES SHOWN IN FIG. 2

(a) Theoretical costs for plunger pumps and induction motors							
Year	1929	1930	1931	1932	1933	1934	1935
Average rate from Fig. 2, bbl per day	39,800	35,200	33,600	29,000	30,800	23,800	31,100
Operating costs:							
Fixed charges: 8 per cent on $440,000	$ 35,200	35,200	35,200	35,200	35,200	35,200	35,200
Labor: 5 men @ $675 per month per station	$ 32,400	32,400	32,400	32,400	32,400	32,400	32,400
Electric power: average kwhr per bbl per 100 miles from Fig. 4 × 1.26 @ 1c per kwhr	$129,000	95,000	84,000	58,600	69,000	33,800	71,600
Maintenance: 50c per hp per year	$ 2,100	2,100	2,100	2,100	2,100	2,100	2,100
Total operating costs	$198,700	164,700	153,700	128,300	138,700	103,500	141,300
(b) Actual costs for centrifugal pumps and induction motors							
Operating costs:							
Fixed charges: 8 per cent on $280,000	$ 22,400	22,400	22,400	22,400	22,400	22,400	22,400
Labor: 5 men @ $675 per month per station	$ 32,400	32,400	32,400	32,400	32,400	32,400	32,400
Electric power: actual kwhr from Fig. 2 @ 1c per kwhr	$208,625	161,770	142,967	103,487	117,903	62,066	120,816
Maintenance: 50c per hp per year	$ 2,400	2,400	2,400	2,400	2,400	2,400	2,400
Total operating costs	$265,825	218,970	200,167	160,687	175,103	119,266	178,016
Accumulated savings in favor of plunger pumps, compounded at 4 per cent annually	$ 67,125	124,020	175,467	214,887	260,403	286,766	334,716
Saving per year by using plunger pumps	$ 67,125	54,270	46,467	32,387	36,403	15,766	36,716

of oil pumped in the Omega line was taken from Fig. 2. The actual operating costs for the Omega line equipped with centrifugal pumps were calculated from data given in Fig. 2. The actual depreciation charges are omitted in this comparison in order that the retirement period of the more costly pumping stations, if any, can be determined more readily. Fixed charges, therefore, consist only of 6 per cent interest, and 2 per cent taxes and insurance, or a total of 8 per cent.

Referring to Table 2, it is noted that in every year of the 7-year life of this line, plunger pumps operated more cheaply than the centrifugal pumps actually operated. In fact, the difference in pumping-station investment ($440,000 — $280,000) of $160,000 could have been retired in 2.4 years had the high capacity factor of 1929 been maintained in the succeeding $1^1/_2$ years. Actually the plunger pumps would have paid for themselves before the end of the third year. Note that in 1934, with an annual average capacity factor of 60 per cent, the savings accomplished by the theoretical plunger-pump stations are the smallest in the 7-year period. In this case, if 10-years' depreciation were added to both annual operating costs, the costs on the centrifugal-pump stations would equal the costs on the plunger-pump station. Therefore, it may be said that plunger-pump installations operated with electric motors would prove more economical than centrifugal-pump stations in almost all cases, since most pipe lines are installed to operate at relatively high capacity factors, usually in excess of 75 per cent during the first few years of their installed life. This conclusion, however, is not definite or fair to present-day centrifugal pumps.

Most centrifugal oil-line pumps today are equipped with induction motors and operate at approximately 3600 rpm, and efficiencies of 75 to 80 per cent are obtainable with such units when volumes of 40,000 bbl per day and larger are pumped. Thus, if centrifugal pumps with a mechanical efficiency of 75 per cent at the maximum rated volume had been available in 1928, the year in which the Omega pipe line was constructed, the overall efficiency of pump and motor would have been (75 × 94, respectively) or about 70 per cent instead of 56 per cent, as given in Table 1 (b) for maximum volume. This increased efficiency would have resulted in a power consumption of perhaps 20 per cent under that shown in Fig. 2.

The higher-speed units would be cheaper to install than the slower-speed units, the approximate saving being $5000 per station, thus giving a total cost of $65,000 per station. The difference in first cost between a pipe line with four stations equipped with high-speed centrifugal pumps and a pipe line with four plunger-pump stations would be ($440,000 — $260,000) $180,000 instead of $160,000. This would extend the retirement period of plunger-pump stations over high-speed centrifugal-pump stations to 14 years or longer, instead of about 3 years, as given in Table 2 for the slow-speed centrifugal-pump stations.

Note that the accumulated annual savings in Table 2, if compounded at 4 per cent, amount at the end of the 7-year period to $334,716 in favor of installing plunger pumps, which in effect is more than twice the increased cost of plunger pumps over centrifugal pumps.

The use of synchronous motors for oil-line pumping is not discussed in this paper. Although it is true that the synchronous motor inherently has a higher efficiency than the induction motor by perhaps several points, the saving in power cost by using synchronous motors may easily be overcome by the fixed charges on the increased first cost of the synchronous motor, coupled with the fixed charges on increased station cost requiring the installation of a fire wall between the motor and pump.

Operating Costs With Oil Engines Driving the Pumps

This paper has dealt with efficiencies of plunger and centrifugal pumps. However, it would not be complete without showing the pumping costs, if oil engines were used instead of motors. The results of electric operation so far indicate that the plunger-pump installation is cheaper to operate, after all factors of annual operation charges are considered including depreciation for a life of 15 to 20 years, than installations using modern highly efficient 3600-rpm centrifugal pumps, and therefore the comparison between motors and engines will be based on using plunger pumps with oil-engine prime movers, and induction-motor prime movers.

The station equipped with oil-engines for driving plunger pumps will be assumed to have three 350-hp engines operating at 250 rpm, each driving 20,000-bbl plunger pumps. The installation cost of each station is $200,000, including working tanks, cottages, and all necessary auxiliary equipment. The brake energy required to be generated by the oil engines will be assumed the same as the electric energy purchased for the induction-motor plunger-pump stations, less the motor losses. Thus, for the sake of simplicity, the electric energy used by plunger pumps for various capacities as shown in Fig. 4 times 0.90 (the average motor efficiency) will be used as the kilowatt-hours per barrel per 100 miles required by oil engines to perform the same work on the Omega line. Table 3 compares the total pumping charges of stations operated with oil engines and stations operated with induction motors, including the cost of the 10-in. pipe line 126 miles long, station costs and all apparent operating costs for the 7-year period of operation of the Omega line. The figures in Table 3 also allow for depreciation over a 20-year period at 5 per cent per year.

Referring to the results given in Table 3, it is noted that electric-driven plunger pumps operate cheaper than pumps driven by oil engines in all of the 7 years with the exception of the first year (1929), when the capacity factor was 100 per cent. In other words, when the annual pumpings are less than about 90 per cent

TABLE 3 ESTIMATED ANNUAL OPERATING CHARGES FOR THE OMEGA PIPE LINE, USING PLUNGER PUMPS OPERATED WITH BOTH INDUCTION MOTORS AND OIL ENGINES

(*a*) Oil engines to plunger pumps							
Year	1929	1930	1931	1932	1933	1934	1935
Average rate for the year, bbl per day	39,800	35,200	33,600	29,000	30,800	23,800	31,100
Operating costs:							
Interest, depreciation, and taxes 13 per cent on 126 miles of 10-in. pipe line @ $10,500 per mile	$172,000	172,000	172,000	172,000	172,000	172,000	172,000
Depreciation (20 year) 5 per cent on station cost of $800,000	$ 40,000	40,000	40,000	40,000	40,000	40,000	40,000
Interest and taxes 8 per cent of station cost of $800,000	$ 64,000	64,000	64,000	64,000	64,000	64,000	64,000
Labor: 8 men per station @ $1125 per month	$ 54,000	54,000	54,000	54,000	54,000	54,000	54,000
Fuel: average cost per bbl by the year	$ 1.48	1.43	0.93	1.13	0.86	1.26	1.26
Fuel cost: kwhr converted from Fig. 4 to bhp-hr, 600 bhp-hr per bbl, @ average cost	$ 38,000	27,200	16,000	13,300	11,700	8,830	17,600
Lubrication: 5c per 1000 bbl per station	$ 2,900	2,560	2,450	2,100	2,250	1,740	2,270
Maintenance: $2 per hp installed per year	$ 8,400	8,400	8,400	8,400	8,400	8,400	8,400
Total operating costs	$379,300	368,160	354,850	353,800	352,350	348,970	357,870
Cost per bbl pumped, cents	2.61	2.86	2.88	3.35	3.12	4.02	3.14
(*b*) Induction motors to plunger pumps							
Operating costs:							
Interest, depreciation, and taxes 13 per cent on 126 miles of 10-in. pipe line @ $10,500 per mile	$172,000	172,000	172,000	172,000	172,000	172,000	172,000
Depreciation (20 year) 5 per cent on station cost of $440,000	$ 22,000	22,000	22,000	22,000	22,000	22,000	22,000
Additional operating expense taken from Table 2 (*a*)	$198,700	164,700	153,700	128,300	138,700	103,500	141,300
Total operating costs	$392,700	358,700	347,700	322,300	332,700	297,500	335,300
Cost per bbl pumped, cents	2.70	2.78	2.83	3.07	2.95	3.42	2.94

of the maximum capacity of the units, the electric-driven plunger pumps operate cheaper for all prices of crude oil used for fuel in the engines, costing $1.43 per bbl in 1930 to 86 cents per bbl in 1933, provided electric power costs approximate 1 cent per kwhr. The fuel costs used were taken as the average market price of crude during the year, plus 10 cents gathering charge per barrel, plus the tariff for transporting the oil one half the distance in the pipe line.

Since the value of fuel is a variable quantity from year to year, it is interesting to compare the price of electric power for the 7-year period with specific values of fuel oil or crude at $1 and $1.50 per bbl, using the capacity factor achieved during this period. These values are plotted in Fig. 5 in order that proper comparisons can be drawn.

From Fig. 5 it will be noted that electric energy should be sold at an average cost of about 0.9 cent per kwhr during 1929 when the capacity factor achieved was 100 per cent, and the value of crude was $1.48 per bbl. In succeeding years, when the average capacity factor was lower than 100 per cent, the electric power would have demanded a higher sale price for the electric operating costs to equal the engine operating costs. In fact, during 1934, when the capacity factor was about 60 per cent, electric power charges could have been about 2.5 cents per kwhr with fuel or crude costing $1.25 per bbl, the average cost of fuel during 1934.

However, the power was purchased at an average cost of 1 cent per kwhr for the entire 7 years, because each month a high electric load factor was attained in each of the pumping stations, and all electric power is usually sold on the basis of load factor attained during the specific month.

The popular conception of power charges for pipe-line pumping is that the rate per kilowatthour should be a fixed amount on a flat basis to enable electrically driven stations to compete with stations equipped with oil-engine units, and therefore, to disprove this theory, the permissible rates per kilowatthour in cents are shown for the 7 years' operation in Fig. 5. Note that such permissible annual average costs of electric energy in Fig. 5 fall on definite curves for the two values of fuel oil considered.

The cost of electric energy at 1 cent per kwhr, being constant value throughout the 7-year period, cuts the curve of permissible electric-energy cost for both values of fuel oil at a capacity factor of about 90 per cent.

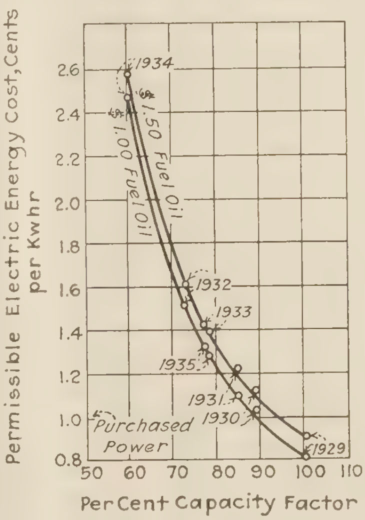


FIG. 5 ELECTRIC-ENERGY COST WHICH WILL PERMIT ELECTRIC OPERATION TO EQUAL OIL-ENGINE OPERATION COSTS

In order that a definite method of determining the actual amount of electric energy required in all pumping stations along a given pipe line for various conditions of capacity can be worked out, the average annual capacity factors for the Alpha pipe line from Fig. 1 and the average annual capacity factors for the Omega line from Fig. 2 are plotted in Fig. 6 against the percentage of maximum electric energy purchased. The curve shown in Fig. 6, drawn as an average between all those points, verifies the assumption made previously, that if the capacity factor expressed as a percentage is raised to the 2.2 power, the resultant percentage will determine the amount of electrical energy required in all stations in terms of per cent of the maximum electric energy required.

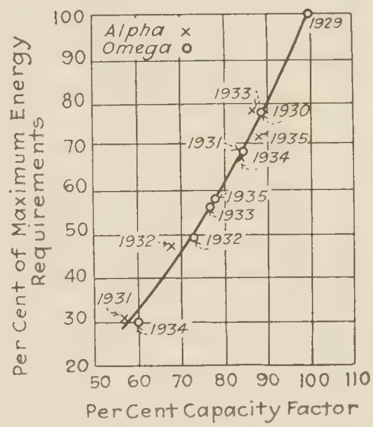


FIG. 6 RELATION BETWEEN CAPACITY FACTOR AND ELECTRIC POWER REQUIRED IN ALL PUMPING STATIONS ON THE ALPHA AND OMEGA LINES

(Per cent maximum electric-energy requirements equals per cent capacity factor raised to the 2.2 power.)

OPERATING COST USING A 12-IN. PIPE

The use of larger pipe diameters and a smaller number of stations has always been considered by pipe-line engineers, but rarely practiced or recommended. Since an attempt was made previously in this paper to determine the actual pumping costs for the 10-in. Omega line with four pumping stations equipped with electrically driven plunger pumps, as given in part *b* of Table 3, a study of comparative costs could readily be made to show the

TABLE 4 ESTIMATED ANNUAL OPERATING CHARGES FOR THE OMEGA PIPE LINE, USING 10-IN. PIPE AND 12-IN. PIPE WITH PLUNGER PUMPS DRIVEN BY INDUCTION MOTORS

(a) Four 700-hp stations pumping through a 10-in. pipe line ($1,765,000 total cost)							
Year	1929	1930	1931	1932	1933	1934	1935
Average bbl per day for the year	39,800	35,200	33,600	29,000	30,800	23,800	31,100
Operating cost:							
Same total costs as shown in Table 3 (b)	$392,700	358,700	347,700	322,300	332,700	297,500	335,300
Cost per barrel pumped, cents	2.70	2.78	2.83	3.07	2.94	3.42	2.95
(b) Two 700-hp stations pumping through a 12-in. pipe line ($1,795,000 total cost)							
Operating costs:							
Interest, depreciation, and taxes 13 per cent on 126 miles of 12-in. pipe line @ $12,500 per mile	$205,000	205,000	205,000	205,000	205,000	205,000	205,000
Interest, depreciation, and taxes 13 per cent on station cost of $220,000	$ 28,500	28,500	28,500	28,500	28,500	28,500	28,500
Labor: 5 men, @ $675 per month per station	$ 16,200	16,200	16,200	16,200	16,200	16,200	16,200
Electric power: kwhr per bbl per 100 miles from Fig. 4 × 0.45 × 1.26 @ 1c per kwhr	$ 57,600	42,700	38,500	26,800	30,800	15,750	31,600
Maintenance: 50c per hp per year	$ 1,050	1,050	1,050	1,050	1,050	1,050	1,050
Total operating costs	$308,350	293,450	289,250	277,550	281,550	266,500	282,350
Cost per barrel pumped, cents	2.12	2.28	2.36	2.63	2.50	3.07	2.48

pumping costs if the Omega Pipe Line Company installed 12-in. pipe and used two pumping stations on the 126-mile line.

Since the working pressures for a 12-in. line are only about 45 per cent of the working pressures of a 10-in. line for given capacities, the kilowatthours per barrel per 100 miles required to pump oil through a 10-in. line using plunger pumps, as shown in Fig. 4, can be converted to kilowatthours per barrel per 100 miles required to pump the same type of crude oil through a 12-in. line and 2 pumping stations, by multiplying the values shown in Fig. 4 by 0.45.

The elevations of stations W, X, Y, and Z of the Omega line indicate that (1) the pumping stations in the 12-in. line could be located at W and Y, (2) that a balanced pressure at each of the proposed pumping stations could be obtained, (3) that the maximum capacity of 40,000 bbl of crude oil with a viscosity of 100 S. sec U. and an A.P.I. gravity of 30 deg could be delivered each day, and (4) that the initial pressures at stations W and Y would not exceed 700 lb per sq in., the maximum allowable working pressure for 12-in. pipe. The comparative costs per year for pumping in the Omega line, for 10-in. and 12-in. pipe, are given in Table 4. The average capacities shown in Fig. 2 were used in making this comparison.

The values in Table 4 indicate that in every year of the operation of the Omega line, the 12-in. pipe line with 2 pumping stations would have operated cheaper than the 10-in. line equipped with four stations. The investment difference is only $30,000 in favor of the smaller line, but this amount is recoverable in operating-cost savings during the first four months of 1929 if the 12-in. line were used.

Again, the results given in Table 4, showing the actual pumping costs for 10-in. pipe through four stations, and 12-in. pipe through two stations, indicate that the larger pipe and a smaller number of stations should be installed. Fig. 7 shows the relation between the velocity of the oil flowing in the 10-in. and 12-in. pipe lines, and the total cost in cents per barrel per 100 miles for both pipe diameters. Note that the lowest operating costs are achieved when the velocity is about 2.5 fps for the average capacity of about 30,000 bbl per day, the actual volume during 1933 and 1935. The fact that lower average pumping charges are achieved with larger pipe and a smaller number of pump stations may lead to the conclusion that the most economical velocity at which to pump oil through pipe lines is somewhere between 2.5 and 3.5 fps.

Conclusion

The mechanical efficiency of plunger pumps is very high and is of the order of 96 to 98 per cent when operated against high pressures.

Again, after analyzing all information and results obtained in this paper, it may be said that plunger pumps driven with electric motors should be installed in trunk-pipe-line stations, if the line is to remain in service 15 to 20 years or longer, and if electric power can be purchased at approximately 1 cent per kwhr for monthly load factors of 75 to 90 per cent. On the other hand, if the proposed pipe line is contemplated to be in use from 5 to 10 years only, and electric power can be purchased for 1 cent per kwhr for monthly load factors of 75 to 90 per cent, the use of centrifugal pumps running at approximately 3600 rpm is economically justified.

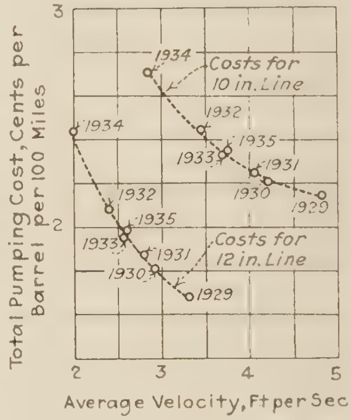


Fig. 7 Comparative Costs for Pumping Oil Through 10-In. and 12-In. Omega Lines

Oil engines to drive plunger pumps should be installed on proposed pipe lines which will have an economic life of 20 years or longer, if cost of crude oil for fuel is estimated not to exceed $1.50 per bbl, and if electric energy is not available or cannot be purchased at high monthly load factors for less than 1 cent per kwhr, and further, if a capacity factor of 90 to 100 per cent can be guaranteed year after year during the entire life, or greater portion of the life of the pipe line.

The history of the Alpha line is that its average capacity factor over 5 years is 77.2 per cent, and the capacity factor of the Omega line is 80.1 per cent over a 7-year period, and yet they are both considered as trunk pipe lines.

Economic use of electric-power facilities on long pipe lines having a number of pumping stations, equipped with either plunger or centrifugal pumps, will now permit definite predictions to be made as to the amount of electric energy required to perform pumping operations when the capacity factor is known, or estimated, by simply raising such capacity factor, expressed as a percentage, to the 2.2 power, to determine the daily, monthly, or annual percentage of the maximum electric-energy requirements for that given period. It is significant that Fig. 6 shows a rapid falling off of total electric-energy requirements when the capacity factor is slightly lowered.

The use of larger pipe diameters and a smaller number of pump stations is fully justified, from a standpoint of receiving a quick retirement of the increased investment of such larger pipe. As a general rule it may be stated that the most economical plan in pipe-line design is to limit the velocity to approximately 3 fps, rather than to use higher velocities of the order of 4 to 5 fps.

Selection of Wood for Industrial Uses

By R. P. A. JOHNSON,[1] MADISON, WIS.

The author discusses the selection of woods for various industrial uses as based upon the physical properties of the woods and requirements which the wood product must meet. He classifies a number of woods according to their warping, end-splitting, turning, planing, and bending qualities, and also rates them in the order of their tendency to transmit odor and taste. Charts are presented which show the distribution of the quantity of wood used in the manufacture of such products as furniture, agricultural implements, automobiles, railroad cars, refrigerators, cabinets, handles, and ladders. The adoption of a wood for the manufacture of a given product and the substitution of one wood for another, based on controlling the physical properties of the wood by treating it, are also discussed.

WISE SELECTION of wood for a given use necessitates first, the determination of the requirements of that use. Good engineering judgment and careful observation are essential to determine which properties are required for satisfactory service and which properties are the most important. The selection of the proper wood is primarily the responsibility of the engineer on the job, because the requirements of use vary with conditions in the plant, the quality of articles produced, and the conditions to which the articles will be subjected in service. The wood best adapted to a given use will, therefore, not always be the same. Ash and southern yellow pine furnish an example of widely different woods used successfully for the same article. Ash is used for bats for college, semiprofessional, and professional ball players. Southern yellow pine serves equally well as ash for bats for small boys of the grade-school age because for children's bats the strength and toughness requirements are not so high. The necessity for careful observation is illustrated in a mistake commonly made in selecting wood for diving boards. Decay-resistant woods are often selected because of the wetting to which the boards are subjected. Diving boards, however, usually fail mechanically in less than two years if they are subjected to continuous use, such as at popular public beaches. The selection of a comparatively high-priced, weak wood of high decay resistance in preference to a low-priced strong wood of moderate or low decay resistance, as is often done, is obviously wasteful, because the purchaser is paying for decay resistance, a property of little or no importance to the use requirement.

[1] Senior Engineer, Section of Industrial Investigations, Forest Products Laboratory. Mr. Johnson received his B.S. degree in civil engineering from Virginia Polytechnic Institute in 1908. He received his M.S. degree in 1928, and a professional degree in civil engineering from the University of Wisconsin in 1931. Since graduation in 1908 he has served continuously in the U. S. Forest Service with ten years service as a forest ranger, land examiner, surveyor-draftsman, and chief of party. For 18 years he has been located at the Forest Products Laboratory conducting researches on the strength of wood, properties and uses of wood, and the selection of wood for farm, home, and industrial uses.

Contributed by the Wood Industries Division and presented at a meeting of The American Society of Mechanical Engineers, held at Niagara Falls, N. Y., September 17 to 19, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until June 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

After the requirements of use are determined, the next step in the proper selection of wood is the determination of a wood with properties which best meet the requirements. Again, good engineering judgment is needed, since it is only in exceptional uses that one wood will excel all others in the properties desired. For example, two important requirements for ladder stock are strength for safety, and light weight for ease in handling. Spruce is light in weight but low in strength when compared with Douglas fir. For each particular type of ladder, it is necessary to determine the importance of the lightweight requirement. Furthermore, the wood best adapted to a use may be higher in price than one which does not meet the requirements so well. The question then is, how much more is the better wood worth? To evaluate the difference in properties, especially when they improve but do not increase the service life, calls for good judgment.

Investigations of the Forest Products Laboratory have resulted in the publication of much information on the properties of wood. This information furnishes a basis for the selection of the wood best adapted to a given use. A large number of the publications contain detailed data on such properties as strength, weight, decay, and painting characteristics. Recently there was published the Wood Handbook,[2] which gives under one cover the accumulation of information previously scattered through a number of bulletins. It contains information on strength, shrinkage, specific gravity, thermal conductivity, electrical resistance, and other properties in units and terms with which the engineer is familiar and knows how to use. No detailed discussion of these properties is possible or necessary in this paper.

Machining and Behavior Properties of Wood

Properties which are not so readily expressed in engineering terms often determine the selection of wood for industrial use. Little has been published on these properties, and it is only through the initiative of the present Wood Industries Division of the A.S.M.E. that any attempt has been made to measure and record them. The absence of engineering data on such properties has resulted in wide differences of opinion as to the extent to which individual species possess or do not possess merit for some particular use. Prejudice and misconceptions regarding such properties have been the cause of considerable loss and poor practice in the use of wood. Recently the Forest Products Laboratory has begun to attack the problem of measuring and recording these properties. The work is still in progress and new methods of measuring, as well as units for recording, have been and must continue to be developed. As a result of the work to date there are now available data which make possible a comparison of a number of hardwood species important in industrial use. The importance of these properties in the selection of wood for some of the industrial uses warrants a brief presentation of the more important properties so far studied.

Warping. Warping is responsible for much waste in fabricating and for some unsatisfactory service. It is defined as: "Any variation from a true or plane surface. Warp includes bow, crook, cup, and twist or any combination thereof." The twist, cup, and bow of samples of southern and Appalachian hardwoods representative of the commercial run of the material were measured and the data combined into the index values shown in Fig. 1.

[2] "Wood Handbook," by Forest Products Laboratory, U. S. Department of Agriculture, September, 1935. For sale by the Superintendent of Documents, Washington, D. C., 25 cents.

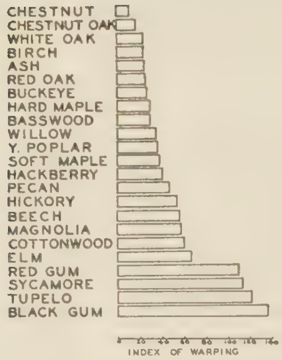


FIG. 1 INDEX OF UNRESTRAINED WARPING OF SOUTHERN AND APPALACHIAN HARDWOODS

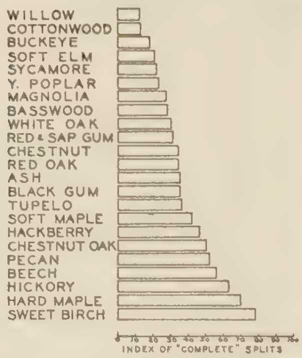


FIG. 2 INDEX OF END SPLITTING OF WOODS AS DETERMINED BY DRIVING SEVEN-PENNY NAILS IN 3/8-IN. STOCK

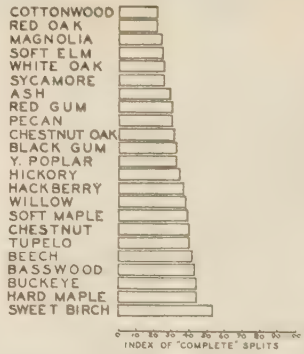


FIG. 3 INDEX OF END SPLITTING OF WOODS AS DETERMINED BY DRIVING SCREWS IN 3/8-IN. STOCK

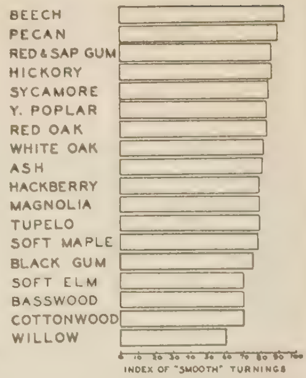


FIG. 4 INDEX OF TURNING QUALITY OF VARIOUS WOODS WHEN USING A MODIFIED BACK KNIFE

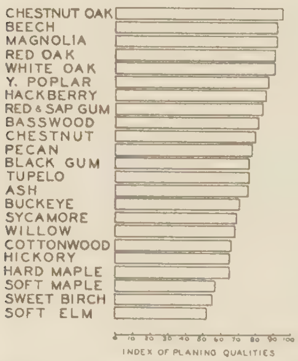


FIG. 5 INDEX OF THE PLANING QUALITY OF VARIOUS WOODS WHEN USING A CABINET PLANER HAVING KNIVES SET AT A 30-DEG ANGLE

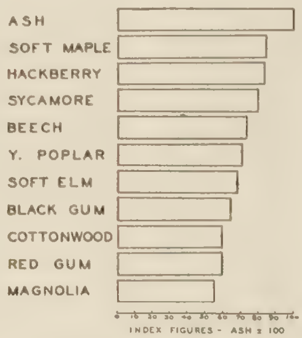


FIG. 6 INDEX OF TENDENCY OF VARIOUS WOODS TO IMPART ODOR OR TASTE AS OBTAINED FROM BUTTER-TAINT TESTS

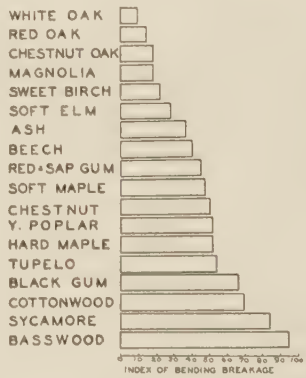


FIG. 7 INDEX OF BENDING QUALITY OF VARIOUS WOODS AS OBTAINED FROM UNSUPPORTED SPECIMENS SELECTED AT RANDOM

The results not only make possible a numerical comparison of species but also show that cross grain is the principal cause of warping, and woods with interlocking grain have the highest index.

Splitting in Nailing. The splitting of wood in nailing adversely affects the strength of joints. Splitting is controllable within limits by the shape of the point and the size of the nails. Additional nails will generally increase the strength of the joint. The splitting tendencies of species are, however, important factors in the selecting of wood for certain uses, notably frames to which upholstery is fastened in furniture and automobiles. Tests using seven-penny box nails in $^3/_8$-in. material and varying distances from the ends resulted in the development of the index values shown in Fig. 2. They are based on the number of complete or through splits. While the index figure may change materially under different test conditions, only minor changes in the relative position of species are to be expected under different test conditions. The application of these results should aid materially in reducing losses resulting from erroneous opinions based on casual observations.

Splitting in Screwing. The splitting of wood by screws adversely affects the strength of joints and fastenings. It is an important consideration in determining the size of lead holes in framing on which heavy doors are to be hung or where hardware is fastened to wood. Some woods which split readily with nails make a much better showing with screws.

The classification of the species in Fig. 3 is based on the complete splits resulting from tests made under severe conditions, namely, with screws of several sizes driven into $^3/_8$-in. stock near the end. The property is important in the manufacture of refrigerators, automobile body frames, boats, and agricultural implements.

Turning. There is considerable difference in the character of surface obtained in turning different woods. The importance of turning qualities in the selection of wood lies in the amount of sanding required to make turnings acceptable and the number of culls. In the past turning qualities have been described only in general terms. The numerical values shown in Fig. 4 were obtained with a modified back knife using specimens conditioned to 6, 12, and 20 per cent moisture content. The results showed that some species, such as beech and pecan, turned well at any moisture content whereas other species, such as willow and cottonwood, give good turnings only at about 6 per cent moisture content. The difference in species can be reduced by drying to a proper moisture content. The property is important in the selection of wood for furniture and interior trim.

Planing. Much better technic is required with some woods than with others to obtain smooth surfaces with a planer. Species differences can be largely eliminated by proper control of speed, moisture content, and cutting angle. High cutter-head speeds (5400 rpm and 54 fpm feed) gave better results than low speeds (3600 rpm and 36 fpm feed). The numerical classifica-

tion shown in Fig. 5 is based on the chip marks, chipped, raised, and fuzzy grain that developed in planing samples at 6, 12, and 20 per cent moisture content with a cabinet planer having knives set at a 30-deg angle and operated at the two speeds just mentioned. It is possible that additional work using different knife angles will show how to reduce further differences due to species. Good planing qualities are desired in practically all industrial uses of wood.

Odor and Taste. A tendency to impart odor or taste bars some woods from a number of industrial uses. The classification shown in Fig. 6 is based on ash as 100 and is the result of tests in which butter was used as a test medium. Butter was used because of its susceptibility to contamination. Woods unsuited for use in butter containers can often be used safely when food does not come in direct contact with the wood such as in refrigerators. Any of the first six woods listed in Fig. 6 can be used satisfactorily for butter containers. Service tests are required to determine the line between acceptable and unacceptable woods for other uses, but any wood acceptable for butter containers can be used safely for other purposes where a tendency to impart odor or taste is objectionable.

Bending. Most hardwoods can be bent readily into a curved form. The comparatively low toughness of softwoods as a group makes them difficult to bend without excessive breakage. The bending index figures shown in Fig. 7 are based on tests of specimens selected at random with only knotty, decayed, and checked pieces excluded. Many of the specimens would not be considered suitable for bending stock because of cross grain they contain. The index shown in Fig. 7 is a measure of the care necessary in selecting and handling the different woods rather than a measure of the waste that would result from their use, because the specimens were bent without end pressure or support on the outside of the bend. Bending operations on carefully selected material, with equipment capable of supplying the proper end pressure and back support, would in all probability result in a much smaller spread between species. The index shown in Fig. 7 is an aid in selecting woods suitable for boat building, certain types of furniture, and other uses.

Use of Data on Machining and Behavior Properties. The numerical values shown in Figs. 1 to 7, inclusive, should not be used for computing waste because limitations are placed on them by test conditions and method of selection. They will in all probability not hold under conditions differing materially from those under which the tests were made. The relative position of species, however, should remain about as shown. The charts should prove a valuable aid until better values resulting from continued work are available in comparing species, and in evaluating properties previously arrived at by guess or superficial observation.

Woods Used by Selected Industries

An important aid in the selection of wood for a given use is a knowledge of woods which are and have been used for the purpose. The woods used indicate fairly well the requirements of the use. When maple, for example, is the principal wood used it indicates that strength and uniform texture are more important than decay resistance and ease of working.

There are available data on the woods used by 48 principal wood-consuming industries. These data, given later in this paper, were collected by Forest Survey of the U. S. Forest Service in cooperation with the Bureau of Census for the years 1928 and 1933. Additional data collected by the states between 1909 and 1913 show the woods used in that period. Ten industries have been selected with the aid of the Wood Industries Division of A.S.M.E. to illustrate the character of data available. The decreased consumption shown in 1933 is largely due to economic conditions. In some uses there has also been a loss of the market for wood.

Furniture. The distribution of woods used in manufacturing furniture is shown in Fig. 8. These woods may be roughly divided into two groups: (1) Woods used for exposed parts, and (2) woods used for concealed parts.

Appearance, style, and finishing qualities are the properties dominating the selection of woods for the first group. Ability to stay in place, nonsplitting, good holding power for screws and nails are important requirements of the second. Properties and use data are of little value in the selection of wood for exposed parts of furniture. The shifts from one wood to another are practically unpredictable from year to year.

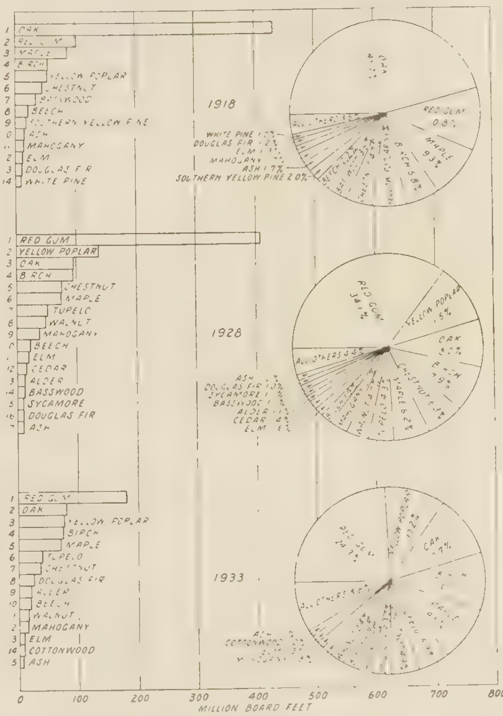


Fig. 8 Distribution of Woods Used in the Manufacture of Furniture

Red gum, yellow poplar, maple, chestnut, and tupelo hold an important place as furniture woods regardless of shifting styles. These woods are used largely for core stock or framing and are selected on the basis of their properties rather than their appearance. Red gum and maple are also used as finish woods.

Motor Vehicles. Strength, uniform working qualities, and high nail- and screw-holding qualities are desired in wood for automobile body frames. Fig. 9 shows oak, red gum, and maple as the principal woods used. Hickory dropped to a minor position with the adoption of wire and disk wheels. The choice between maple, oak, ash, and elm is largely one of availability and cost. The woods are used interchangeably, sometimes all three being used in a single built-up part. Maple is generally preferred because of its uniformity, working qualities, and high strength. Red gum has the advantages of low weight combined with medium strength and nail-holding power. These combined with price and uniform texture are responsible for its use in low-priced cars.

Railroad-Car Construction. The outstanding woods for railroad-car construction and repair are southern yellow pine and Douglas fir as shown in Fig. 10. Availability and price are probably a larger factor in the extensive use of these woods than their

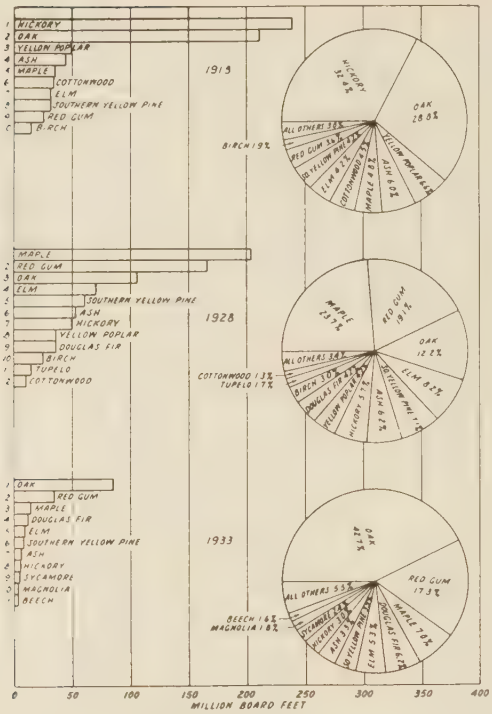


FIG. 9 DISTRIBUTION OF WOODS USED IN THE MANUFACTURE OF AUTOMOBILES

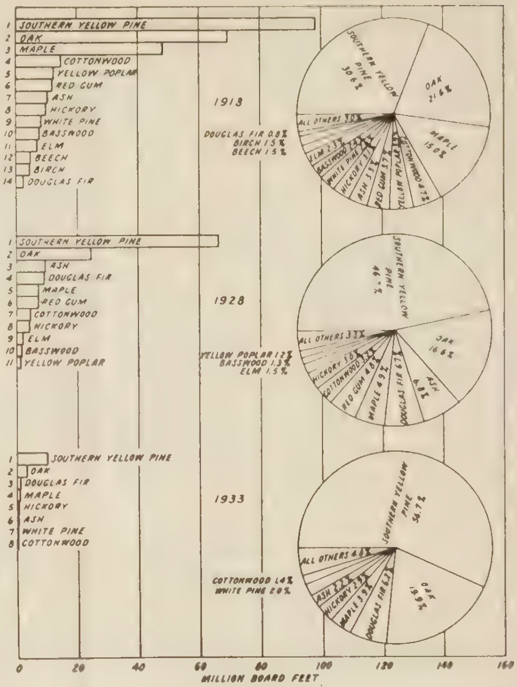


FIG. 11 DISTRIBUTION OF WOODS USED FOR AGRICULTURAL IMPLEMENTS

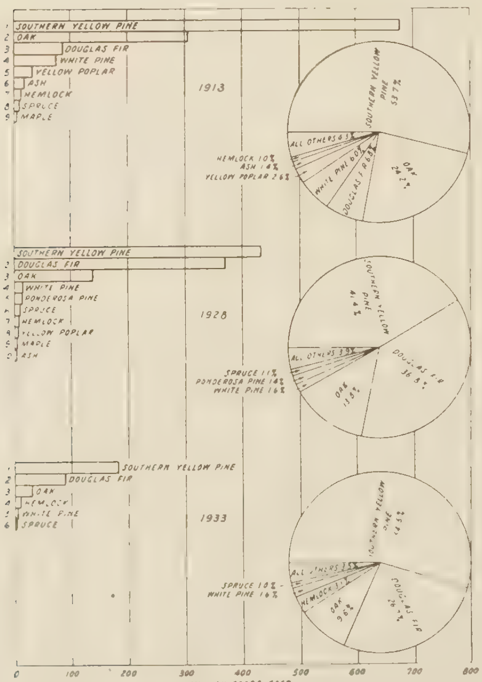


FIG. 10 DISTRIBUTION OF WOODS USED IN THE CONSTRUCTION AND REPAIR OF RAILROAD CARS

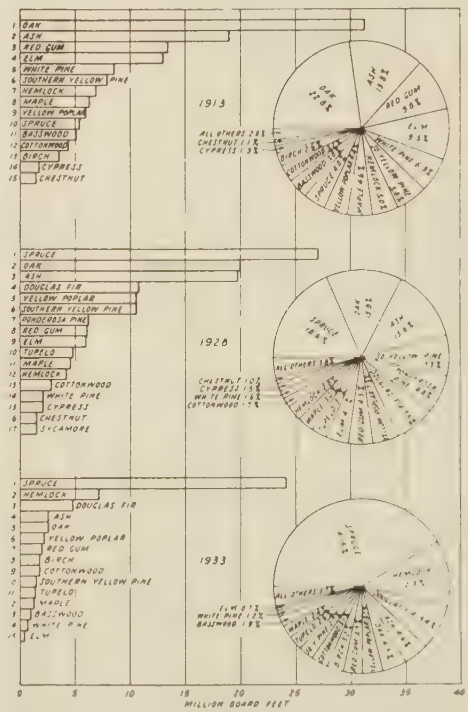


FIG. 12 DISTRIBUTION OF WOODS USED IN THE CONSTRUCTION OF REFRIGERATORS AND KITCHEN CABINETS

strength, decay resistance, and ease of fabrication. Oak is still used in frames for its shock-resisting and high nail- and screw-holding qualities. The substitution of steel for oak is largely responsible for the percentage decrease in its use as shown in Fig. 10.

Agricultural Implements. The requirements for agricultural

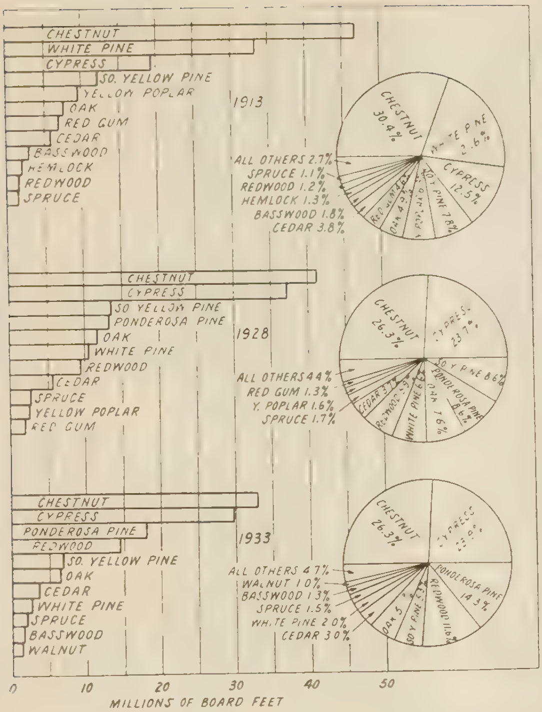


Fig. 13 Distribution of Woods Used for Caskets and Coffins

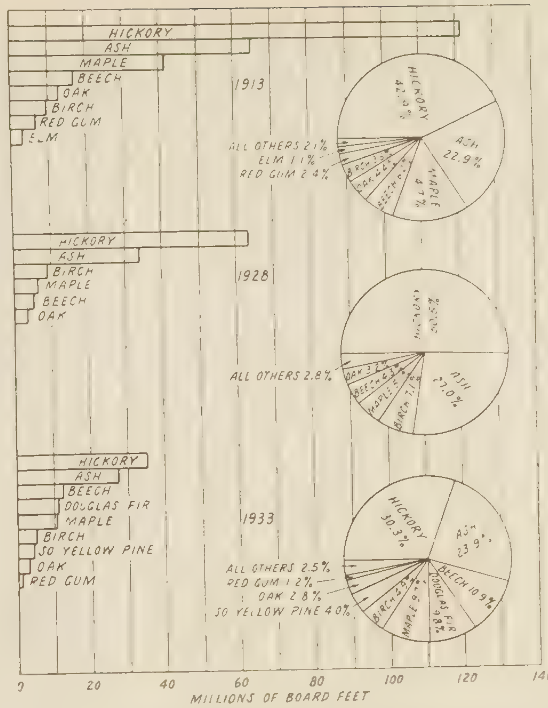


Fig. 15 Distribution of Woods Used for Handles

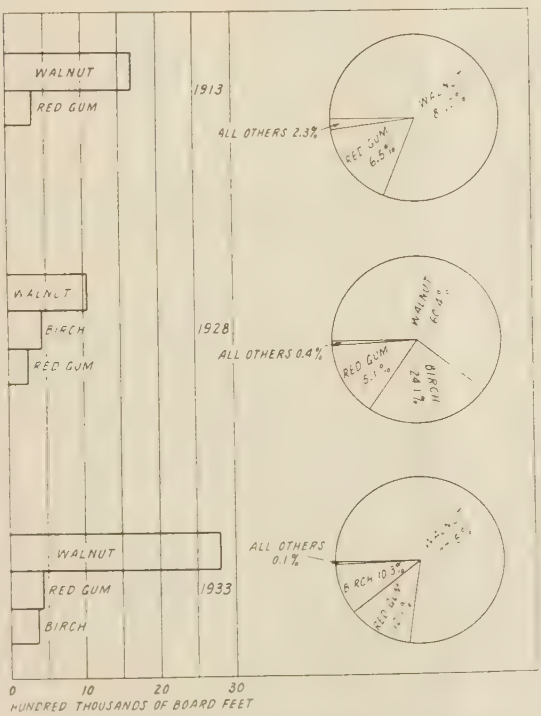


Fig. 14 Distribution of Woods Used in Firearms

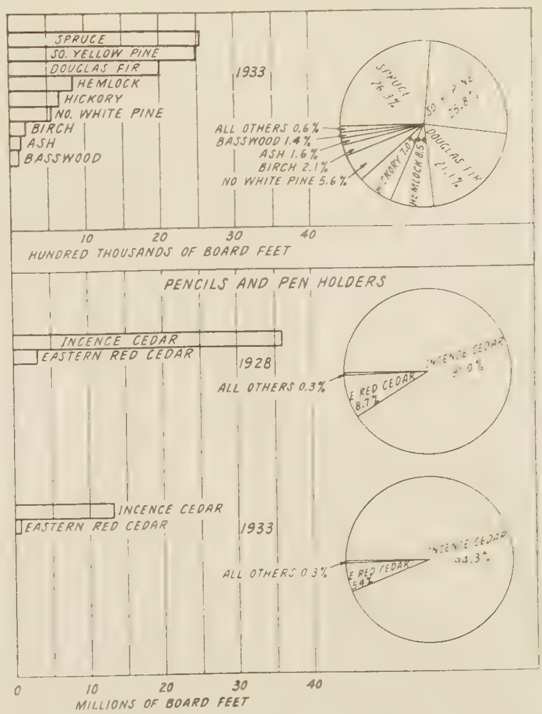


Fig. 16 Distribution of Woods Used for Ladders, Pencils

implements differ with individual units. Hay rakes, threshing machines, and seed drills not only differ widely in their requirements but the requirements of individual partsal so differ. It is difficult to generalize over such a wide range. Fig. 11 shows that southern yellow pine and oak are the woods most extensively used. Oak is used because of its toughness and southern yellow pine because of its ease of seasoning, light weight, moderate strength, and price.

Refrigerators. The wood requirements for refrigerators have been entirely changed by electric refrigeration. The steel cabi-

net has replaced the wood cabinet, which accounts for the reduction in the use of oak, ash, and elm shown in Fig. 12. The predominating woods are now spruce, hemlock, and Douglas fir. These woods are used for frames. The hemlock and spruce differ little in strength. Hemlock is slightly heavier and stronger than spruce but the latter is stronger for its weight. Neither spruce nor hemlock impart any objectionable odor or taste to food. Both woods are low in decay resistance. Douglas fir is stronger and has more decay resistance than spruce or hemlock, but it has a slight resinous odor. The principal woods used are selected because of their availability and price rather than their properties, although woods with a strong odor are banned.

Caskets and Coffins. Decay resistance is considered the most important requirement for caskets and coffins. It is responsible for the extensive use of chestnut and cypress, as shown in Fig. 13. Observations made on caskets and coffins removed from a burial ground after 20 years indicate the failures that had occurred were principally mechanical. Where decay was responsible for failure, it was found that all heart grades had not been used. The mechanical failures do not indicate the necessity of selecting other species, but rather the necessity of improved bracing and design.

The trend toward uncovered hardwood caskets introduces a new requirement. Appearance is important in uncovered wood caskets and will result in an increased use of woods with high or moderate decay resistance, as black walnut, chestnut, white oak.

Firearms. Black walnut, as shown in Fig. 14, is the outstanding wood used in firearms. It meets the requirements for beauty, stability, and hardness. Birch and red gum are used in lower-priced guns. Birch has the hardness but lacks the stability of walnut. Red gum has neither the hardness nor the stability of walnut, but is used as a substitute because it can be finished to closely resemble walnut.

Handles. Hickory and ash stand out from other woods in their ability to meet exacting requirements of handles as shown in Fig. 15. Hickory is outstanding because of its combination of toughness, stiffness, and breaking strength, all of which are required in axe, maul, and similar handles. In addition, hickory turns well and wears smooth. Ash is outstanding because of its high toughness and breaking strength, for its weight, and its low warping, all of which are the requirements for pitch forks, rakes, hoes, and other long handles subjected to heavy use. Beech, birch, and maple are extensively used for hammers, small tools, and other short handles where smoothness in turning is more important than weight or toughness.

Pencils and Pen Holders. The requirements for good pencil wood, as stated by manufacturers, are even texture, straight grain, softness, slight brittleness, dark red in color, slightly aromatic, and light weight. The requirements that wood be dark red in color and slightly aromatic are interesting in that they have nothing to do with the serviceability of a pencil.

Eastern red cedar was and is still considered the outstanding pencil wood of the world. Incense cedar has supplanted eastern red cedar as shown in Fig. 16, not because it is considered better, but because of an inadequate supply of eastern red cedar. Brittleness is also a questionable requirement because the preferred eastern red cedar is more than twice as tough as incense cedar. Eastern red cedar is also the hardest of the cedars, indicating, that within limits, hardness is not so important as it is rated. The search for a substitute for eastern red cedar has been complicated by an erroneous conception of the actual property requirements. Any of the cedars, a number of junipers, redwood, and white pine all have properties favorable to their use as pencil woods. Prejudice prevents their serious consideration.

Ladders. The properties that contribute to satisfactory service have been used to classify woods for use in ladder construction. The classification groups woods for side rails on the bases of the required percentage increase or permissible decrease of requirement for spruce for each cross-sectional dimension.[3]

Spruce is not only the standard but is also the principal wood used in the construction of ladders, as shown in Fig. 16. Its high ratio of strength to weight is largely responsible for its high rating as a ladder wood. Its light color is responsible for the demand for light-colored wood for ladders, although color has no service value and appearance is of minor or no importance in ladders. Western hemlock, which ranks next to spruce in the use of wood for ladders, makes an excellent substitute for spruce. While the properties of western hemlock do not meet ladder requirements as well as spruce, some manufacturers have found it easier to obtain satisfactory hemlock than spruce, principally because the best quality of spruce is selected for airplanes and other more exacting uses. Southern yellow pine and Douglas fir are used in ladders where the strength-weight ratio is not so important. They make stronger but heavier ladders.

Rungs and cleats of ladders are of hard woods, white ash being used as a standard. Fig. 16 shows that hickory is the principal wood used for this purpose. Hickory is superior to ash in strength and wearing qualities. It is, however, heavier and does not have as favorable a strength-weight ratio.

Significance of Species Used. The extensive use of wood for a given purpose indicates that it has been found acceptable by the cut-and-try method. It does not necessarily indicate that it is the best wood for the use. The best wood may be too high priced or the cut-and-try system may not have considered all possible woods, or a wood previously not readily available perhaps now is obtainable.

The selection of wood to replace one that has proved satisfactory is fairly simple. The properties of available woods are compared with those of the wood in use. The selection of the best substitute requires good judgment in evaluating the differences in properties, especially the elimination of the nonessential properties. When a wood in use is not satisfactory, the selection of a wood that will give satisfactory service depends on a knowledge of the exact cause of failure. Strange as it may seem, decay-resistant wood of the same or lower strength is often selected to replace a wood that has failed mechanically. Moreover, woods which are non-decay-resisting are often selected to replace woods that are being replaced because of decay.

The Importance of Species

The general tendency is to overemphasize the importance of species. The importance of small differences in species is magnified, the variability of wood of species is ignored, and there is a tendency to assume that all wood of one species is superior to all wood of another. There is always considerable overlapping in strength and other properties of all competitive species. Well-selected wood of an inferior species is better than poorly selected wood of a superior species.

Design and treatment are great equalizers of species. A well-designed article made of a comparative inferior species will usually give better service than a poorly designed article made of a superior species. Differences in strength can be compensated for by differences in size. Differences in decay resistance can be compensated for by treatment and better protection from moisture. Differences in working qualities can be compensated for by the control of the speed of machinery, angles of knives, and moisture content of stock. Warping and shrinkage tendencies can be partly controlled by selection. With the exception of a few uses with exacting requirements any one of a number of woods can be used if proper design and treatment are applied.

[3] "Safety Code for the Construction, Care and Use of Ladders," Bulletin No. 351, October, 1923. Department of Labor, Bureau of Labor Statistics, Washington, D. C.

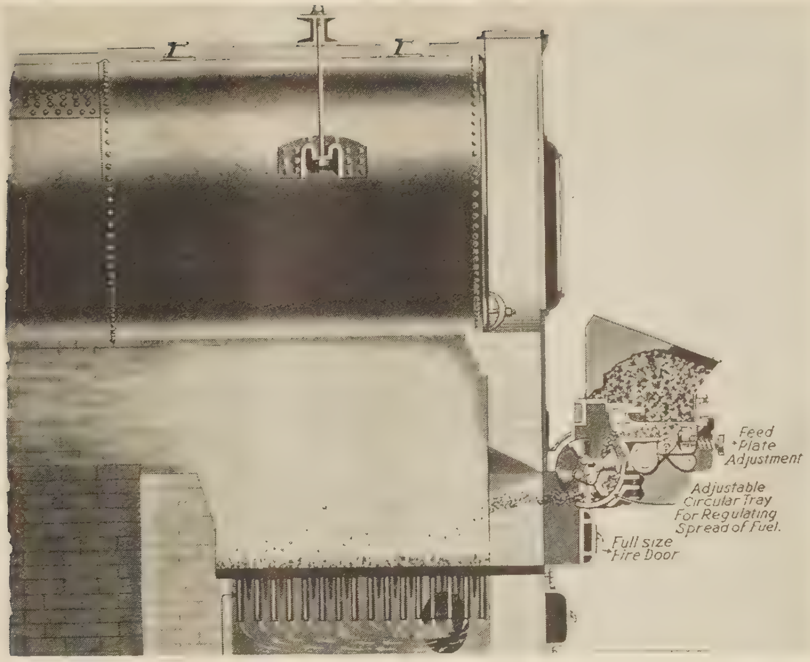


Fig. 1 Underthrow Spreader Stoker With Paddles Revolving So As to Throw the Coal at the Bottom Point of the Revolution

The Forced-Draft Spreader Stoker[1]

By J. F. BARKLEY,[2] WASHINGTON, D. C.

The author discusses the types of spreader stokers in use together with their adaptability for different boiler installations and for burning different grades of fuel. He presents the reasons for their adoption in various Government plants where boilers range in capacity from 100 to 400 hp. The paper contains a table of data showing the results of a number of complete boiler tests conducted on installations equipped with spreader stokers.

THE TERM "forced-draft spreader stoker" as used in this paper covers forced-draft fuel-burning equipment in which the fuel is spread or thrown into a combustion space, part of the fuel burning in suspension somewhat similar to pulverized-fuel applications and part dropping onto a high-resistant type of grate on which the burning is completed. The fuel may be thrown in by revolving paddles or may be blown in with air. Some of the air required for combustion is supplied over the grate, and the remainder comes up through the grate.

The most interesting and effective development period of this type of stoker in this country reaches from, say, 1929, when there were relatively few such applications, up through the last two or three years, during which the rise in the number of sales, relative to other types of stokers, has been remarkably great. Previous to this somewhat arbitrarily chosen period, there were various developments leading toward the spreader stoker. Some of the first attempts to fire coal mechanically included schemes to imitate the fireman's throwing in of coal onto a grate. Revolving paddles turning at very low speeds appeared many years ago. Later, some natural-draft hand-fired bituminous-coal installations were improved by the use of paddles revolving at high speeds. The pinhole type of grate for hand-fired installations using forced draft early came into being for burning fine anthracite. It was when the combination of high-speed paddle and pinhole grate was applied to the burning of bituminous coal by J. A. Hoffman, of the Detroit Edison Company, that combustion events were noted that have led to the present status of the spreader stoker. It was found that there was considerable suspension burning; that the ash particles falling to the grate assumed a fluffy appearance; that the fuel bed on

[1] Published with the permission of the Director, U. S. Bureau of Mines, Washington, D. C.

[2] Supervising Engineer, Fuel Economy Service, U. S. Bureau of Mines. Mem. A.S.M.E. Mr. Barkley holds the degrees of B.S. and E.M. from the Michigan College of Mines. In 1911 he served as an instructor in the New Mexico School of Mines and for the next two years was associated with the Westinghouse Electric & Manufacturing Co. After four years with the Bureau of Mines he took the position of special engineer with the Carnegie Steel Co., where he remained until 1923. In his present capacity he serves as consultant on design, operation, and fuel use in federal fuel-burning plants. He is a member also of the A.I.M.E. and has contributed articles to Bureau of Mines publications and technical magazines in the fuel field.

Contributed by the Fuels Division for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until July 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

the grate could be kept surprisingly level, the dancing of the fuel particles thereon aiding the spreading effects of the paddles; that a thin bed of burning fuel could be maintained on the grate, beneath which was a bed of ash that gradually increased in thickness; that the ash was kept relatively cool due to the high proportion of air coming up through the grate, the high temperatures of burning being well above it; that the carbon in the refuse could be quickly burned out to very low amounts by stopping the coal feed; that good CO_2 could be obtained, the equipment being quite sensitive to adjustment; that quick responses to load changes could be had; that a wide range of coals could be used, the caking characteristics being of no particular moment and the ash fusion little more; that the maintenance of the grate and spreader equipment, both being out of the fire, was practically negligible; and that the operation was simple and readily understood by the ordinary small-job fireman. Such inherent characteristics and advantages warranted development studies; it might be noted at this point that inherent freedom from smoke and fly-ash emission is not listed. Fig. 1 might be considered representative of the beginning stages of the development. As installed under the horizontal-return-tubular boiler, ample space for flame length and combustion was provided; the combustibles and overfire air supplied near the coal feed passed at right angles over the grate from which the air and gases rose vertically; ratings were relatively low, and most of the fly ash fell into the back chamber where its carbon content slowly burned out. A simple on-and-off control based on the steam pressure was used, a setting being made on the spreader for a chosen rate of coal feed and on the forced-draft air inlet for a chosen rate of air. Two sets of revolving paddles were desirable. The fire was cleaned one side at a time; the coal feed to one set of paddles was cut off for a few minutes, during which time the carbon in the ash on that side of the grate was burned out. This ash was pulled out the upper door with a few pulls of a hoe, usually onto the boiler-room floor. If for any reason the paddles could not be operated, hand-firing could be done through the upper doors.

The modest beginnings of the establishment of the stoker's place in the fuel-burning industry might be illustrated by experiences of the federal government as purchaser and user. The government operates a great number of small plants located over the entire United States, having boilers from about 100 hp up to, say, 400 hp. Many different coals must be used; a considerable number of these plants are rather isolated, some being many miles from a railroad. Trouble was experienced in the plants due to equipment maintenance, continual replacements of parts, fireman inabilities, prejudices and complaints, ash and clinker troubles, low efficiencies, and difficulties in choosing coal. Frequently, solutions of individual cases resulted in buying some particular and expensive coal. The spreader stoker came to the attention of the federal government. With perhaps some justifiable misgivings, a study was made of it and installations were inspected. It was quite apparent that the use of this stoker would be an improvement, relieve many plant troubles and not merely replace them with some other kind of troubles. An installation was made under a 200-hp cross-drum water-tube boiler at an Indian reservation near Mt. Pleasant, Mich. It was an immediate success. Young, inexperienced Indian boys served as firemen. The coal used was the cheapest west Kentucky slack having an ash content of about 15 per cent and an ash fusion of approximately 2000 F. The equipment operated satisfactorily; it was easy to carry the plant load continually, maintenance costs practically disappeared, and total costs were low. Based on these experiences the government began installing these stokers in chosen places all over the United States, burning coals from anthracite rice to lignite slack. They were ideally suited, for example, to the federal penitentiaries. Convict firemen could easily operate them; any temptation to "accidentally" cause the breakage of a part that would stop the stoker was put out of mind by the thought that it would then be necessary to fire by hand through the upper doors.

The continued installing of such an unorthodox stoker brought up many questions, particularly to and from competitors of other types of equipment. What actual efficiencies could be shown by tests? What CO_2 could be maintained without CO? What about fly ash and smoke? All of these questions were interesting and were to be answered as developments permitted. Using again the government as an example, it was quite apparent at the time that such technical considerations could have only slight effect on the general result for the cases at hand. Troubles were being eliminated and money saved. It was not what could be shown by tests but what actually happened at a plant over a period of time.

As the use of the spreader stoker broadened, new problems of application brought new developments and refinements. These exact details varied with the several manufacturers entering the field. Engineers were slow to realize the importance of the type of grate, especially for the more exacting requirements. A high-resistant grate meant practically a uniform air flow throughout the grate area, regardless of any temporary irregularities in the resistance or thickness of the fuel bed, and better cooling effect was obtained; the higher velocity air also gave better dancing of the particles. Air zoning came into use; that is, an air zone for each spreader, making in effect two or more stokers per boiler. It has been found that preheated air can be successfully applied to this type of stoker. Grate areas were usually made liberal for most small boilers, extending across the width and from about 6 to 8 ft deep for cases where the ash was pulled out by hand. Where the loads were unexpectedly low, it was occasionally found advantageous to brick off some of the grate area. For the larger boilers, questions arose regarding the pounds of coal per square foot of grate area and depth of spreading capacity of the spreader. Tests are recorded of the burning of as high as 100 lb of coal per sq ft of grate area per hr. A depth of spread of about 12 ft has been used. Dumping grates appeared, both hand- and power-operated. Ash could be quickly and easily dumped into hoppers beneath the boiler-room floor. This was of particular advantage for the deeper grates and larger boiler installations. Where the ash must be hoed onto the boiler-room floor for disposal, it seldom is of advantage first to dump it into the plenum chamber, to be hoed out later. With the higher burning rates and temperatures, some clinkering difficulties began to appear, especially with the higher-ash coals of low ash-fusion temperatures. If the ash bed was allowed to build up too thick or remain on the grate too long some clinkering might occur. More frequent dumping solved many such cases. An air-cooled carborundum brick along the grate line was used for other cases. Larger boiler installations, running at high ratings are now equipped with water-cooled furnaces.

Since the spreader stoker is an overfeed stoker, the engineering problem of preventing smoke production was early encountered. From the standpoint of smoke emission, the spreader stoker operates something like an oil burner—it is very sensitive to the human element. A slight turn of the hand, giving too much fuel feed for the air, immediately gives excessive smoke. Vertically baffled boilers usually do not provide the length of flame travel or the same kind of mixing provided by the long, horizontal combustion chamber of horizontal-return-tubular boilers. The high load-carrying capacity of the stoker tempted firemen to carry higher loads and use fewer boilers than planned. This

TABLE 1 TESTS OF FORCED-DRAFT SPREADER STOKERS

Item No.	Unit	1	2	3	4	5
1. Test No.		1	2	3	4	5
2. Remarks		Data from regular operation - considerable load variation				Veteran's Administration test-fairly uniform load
3. Date		Mar.21&22,1933	Apr.1-3,1933	Apr.6-8,1933	Mar.6-7,1933	Jan.16,1935
4. Duration	hrs.	27.67	48.00	48.00	24.00	12
5. Type of boiler		Cross Drum Water Tube				Four Drum Water Tube
6. Type of baffling		Vertical				
7. Grate surface	sq.ft.	67.5				85
8. Type of fuel	coal	Anthracite Buckwheat #2	Anthracite Buckwheat #3	Mixture 35% Anthracite #4; 65% Bituminous 2" NAS	Bituminous 2" NAS	Semianthracite 3/8" culm
9. Boiler heating surface	sq.ft.	2610				
10. Ratio of heating surface to grate surface		42.5				
11. Setting height	ft.	10'-0"				12'-0"
12. Combustion space volume (approximate)	cu.ft.	508				1377
13. Heat release (approximate)	B.t.u./cu.ft./hr.	39900	31300	34700	34400	15900
14. Smoke by Ringelmann chart (approximate average)						0.8
Average Pressures and Temperatures:						
15. Steam pressure by gage	lbs./sq.in.	98.3	100.0	101.0	102.0	95
16. Force of draft - combustion chamber	"H_2O	-0.08	-0.04	-0.06	-0.13	-0.11
- boiler setting ahead of damper	"H_2O	-0.18	-0.15	-0.17	-0.23	-0.71
16a Pressure of air at stoker grates - left side	"H_2O	1.06	1.15	0.45	0.28	0.7
- right side	"H_2O	1.06	1.15	0.45	0.28	0.7
17. Temperature of feed water entering boiler	°F.	174.0	167.5	167.0	173.0	48
18. " " calorimeter	°F.					287
19. " " escaping gases leaving boiler	°F.	570	540	597	610	477
20. " " boiler room	°F.	56	66	63	62	61
Quality of Steam:						
21. Percentage of moisture in steam	%					0.25
22. Factor of correction for quality of steam		0.9875	0.9875	0.9875	0.9875	
Total Quantities:						
23. Total weight of coal as fired	lbs.	44460	60835	64852	30190	22842
24. Percentage of moisture in coal as fired	%	6.7	7.0	6.3	1.8	5.9
25. Total weight of dry coal	lbs.	40592	56019	60766	29647	21494
26. " " " ash and refuse from stoker grates	lbs.					3155
26a " " " fly ash from back chamber	lbs.					
27. Percentage of ash and refuse from grates based on dry coal	%					14.7
27a " " fly ash from back chamber " " " "	%					
28. Total weight of feed water	lbs.	355530	449600	537583	282552	147000
29. " water evaporated corrected for steam quality	lbs.	321461	443980	530863	279070	146642
30. Factor of evaporation		1.079	1.086	1.087	1.081	1.205
31. Total equivalent evaporation from and at 212°	lbs.	346856	482162	577046	301621	176763
32. Percentage of steam used by jets based on steam produced (approximate)	%					
Hourly Quantities and Rates:						
33. Dry coal per hour	lbs.	1467	1157	1266	1235	1792
34. " " " sq.ft. of grate surface per hour	lbs.	21.7	17.3	18.8	18.3	21.1
35. Equivalent evaporation from and at 212° per hour	lbs.	12539	10045	12022	12568	14725
36. " " " per sq.ft. of boiler heating surface	lbs.	4.37	3.50	4.19	4.36	
Capacity:						
37. Rated boiler horsepower	hp.	287	287	287	287	400
38. Boiler horsepower developed	hp.	363.3	291.2	348.5	364.3	427
39. Percentage of rated capacity developed	%	126.6	101.5	121.4	126.9	107
Economy:						
40. Water fed per lb. of coal as fired	lbs.	7.38	7.46	8.29	9.36	
41. " evaporated per lb. of dry coal	lbs.	7.98	7.93	8.74	9.41	6.82
42. Units of evaporation per lb. of coal as fired	lbs.	7.80	8.00	8.90	9.99	7.74
43. " " " " " dry coal	lbs.	8.54	8.61	9.50	10.17	8.22
44. Analysis of Dry Gases by Volume:						
a. Carbon dioxide (CO_2)	%	8.10	8.45	8.60	10.80	11.0
b. Oxygen (O_2)	%	12.33	11.73	11.42	8.72	
c. Carbon monoxide (CO)	%	0.00	0.00	0.00	0.00	
d. Nitrogen (N_2) by difference	%	79.57	79.82	79.98	80.48	
45. Lbs. of dry flue gases per lb. of carbon	lbs.	30.65	29.41	28.91	23.21	
46. " " " " " " dry coal	lbs.	23.29	21.50	22.26	17.83	
47. Proximate Analysis of Coal as Fired:						
a. Moisture	%	6.7	7.0	6.3	1.8	5.9
b. Volatile matter	%	5.2	8.0	16.0	22.7	10.0
c. Fixed carbon	%	78.4	74.5	68.7	66.2	65.1
d. Ash	%	7.6	10.5	9.0	9.3	19.0
48. Ash softening temperature	°F.				2350	2800
49. Ultimate Analysis of Dry Coal:						
a. Carbon	%	85.1	81.7	80.5	78.8	72.3
b. Hydrogen	%	2.4	3.3	3.9	4.6	3.3
c. Oxygen	%	2.4	2.0	2.6	2.6	2.6
d. Nitrogen	%	0.9	1.2	1.1	1.2	0.7
e. Sulphur	%	0.7	1.0	2.3	3.3	0.9
f. Ash	%	8.5	11.3	9.6	9.5	20.2
50. B.t.u. per lb. of dry coal	B.t.u.	13670	13630	13920	14130	12250
51. Proximate Analysis of Fly Ash from Back Chamber:						
a. Moisture	%	0.0			0.0	
b. Volatile matter	%					
c. Fixed carbon	%					
d. Ash	%	16.1			46.0	
52. B.t.u. per lb. of dry fly ash from back chamber	B.t.u.					
53. Analysis of Dry Ash and Refuse from Stoker Grates:						
a. Combustible	%	51.8	41.7	26.9	17.6	17.1
b. Ash	%	48.2	58.3	73.1	82.4	82.9

Item No.	Unit	6	7	8	9	10
1. Test No.		6	7	8	9	10
2. Remarks		Cross-fire steam jets used	Bureau of Mines tests - uniform load			Veteran's Administration test-fairly uniform load
3. Date		Jan.15,1937	May 29,1935	June 6,1935	May 31,1935	Jan.31,1934
4. Duration	hrs.	11.98	11.57	12.00	4.18	6
5. Type of boiler		Cross Drum Water Tube				Low Head Type Water Tube
6. Type of baffling		Vertical				
7. Grate surface	sq.ft.	52.9	39.0			90
8. Type of fuel	coal	Bituminous 3/4" slack				Bituminous 1¼" slack
9. Boiler heating surface	sq.ft.	2510	2000			
10. Ratio of heating surface to grate surface		47.8	51.3			
11. Setting height	ft.	9'-6"	9'-6"			10'-0"
12. Combustion space volume (approximate)	cu.ft.	410	284			911
13. Heat release (approximate)	B.t.u./cu.ft./hr.	38600	49300	81600	107800	22800
14. Smoke by Ringelmann chart (approximate average)		1.1	1.7	3.6	5.0	
Average Pressures and Temperatures:						
15. Steam pressure by gage	lbs./sq.in.	114.5	113.8	115.7	105.0	100
16. Force of draft - combustion chamber	"H_2O	-0.020	-0.189	-0.375	-0.094	-0.135
- boiler setting ahead of damper	"H_2O	-0.073	-0.302	-0.478	-0.464	-0.273
16a Pressure of air at stoker grates - left side	"H_2O		0.72	-0.91	1.46	1.03
- right side	"H_2O	0.61	0.69	0.98	1.42	1.03
17. Temperature of feed water entering boiler	°F.	55.7	64.0	64.3	63.7	122.7
18. " " calorimeter	°F.	293.3	292.6	290.5	274.3	270
19. " " escaping gases leaving boiler	°F.	481	590	725	755	484
20. " " boiler room	°F.	69.8	83.0	77.8	82.6	63
Quality of Steam:						
21. Percentage of moisture in steam	%	0.23	0.26	0.40	1.11	1.26
22. Factor of correction for quality of steam		0.99828	0.99804	0.99699	0.99159	
Total Quantities:						
23. Total weight of coal as fired	lbs.	14778	12797	21762		12263
24. Percentage of moisture in coal as fired	%	6.5	3.7	3.6		10.2
25. Total weight of dry coal	lbs.	13817	12324	20979		11012
26. " " " ash and refuse from stoker grates	lbs.	1873	1662	2078		1850
26a " " " fly ash from back chamber	lbs.	393	510	1280		
27. Percentage of ash and refuse from grates based on dry coal	%	9.2	11.9	9.9		16.8
27a " " fly ash from back chamber " " " "	%	2.8	4.3	6.1		
28. Total weight of feed water	lbs.	185084	96269	150700	60097	87009
29. " water evaporated corrected for steam quality	lbs.	184869	96080	150246	59592	85913
30. Factor of evaporation		1.2000	1.1946	1.1945	1.1937	1.13
31. Total equivalent evaporation from and at 212°	lbs.	149843	114777	179469	71135	97082
32. Percentage of steam used by jets based on steam produced (approximate)	%	2.4				
Hourly Quantities and Rates:						
33. Dry coal per hour	lbs.	1153	1065	1748		1875
34. " " " sq.ft. of grate surface per hour	lbs.	22.0	27.3	44.8	Approx. 58.3	20.4
35. Equivalent evaporation from and at 212° per hour	lbs.	12508	9920	14956	17018	16180
36. " " " per sq.ft. of boiler heating surface	lbs.	4.98	4.96	7.48	8.51	
Capacity:						
37. Rated boiler horsepower	hp.	251	200	200	200	400
38. Boiler horsepower developed	hp.	362.6	287.5	433.5	493.3	469
39. Percentage of rated capacity developed	%	144.5	143.8	216.8	246.7	117
Economy:						
40. Water fed per lb. of coal as fired	lbs.	8.46	7.52	6.92		
41. " evaporated per lb. of dry coal	lbs.	9.04	7.80	7.16		
42. Units of evaporation per lb. of coal as fired	lbs.	10.14	8.97	8.25		7.92
43. " " " " " dry coal	lbs.	10.84	9.31	8.55		8.82
44. Analysis of Dry Gases by Volume:						
a. Carbon dioxide (CO_2)	%	14.29	10.70	12.02	13.06	11.4
b. Oxygen (O_2)	%	4.48	8.66	5.88	4.38	
c. Carbon monoxide (CO)	%	0.12	0.04	0.48	0.90	
d. Nitrogen (N_2) by difference	%	81.11	80.60	81.62	81.64	
45. Lbs. of dry flue gases per lb. of carbon	lbs.	17.62	23.32	20.11		
46. " " " " " " dry coal	lbs.	12.67	15.63	12.93		
47. Proximate Analysis of Coal as Fired:						
a. Moisture	%	6.5	3.7	3.6	3.6	10.2
b. Volatile matter	%	27.4	29.1	29.4	24.1	32.5
c. Fixed carbon	%	56.2	53.5	54.4	60.2	37.9
d. Ash	%	9.9	13.7	12.6	12.1	19.4
48. Ash softening temperature	°F.	2660	2300	2380		Approx. 2100
49. Ultimate Analysis of Dry Coal:						
a. Carbon	%	77.7	72.8	73.7		61.8
b. Hydrogen	%	4.8	4.8	4.9		4.4
c. Oxygen	%	4.3	3.9	3.9		6.6
d. Nitrogen	%	1.5	1.4	1.4		1.1
e. Sulphur	%	1.1	2.9	3.0		4.5
f. Ash	%	10.6	14.2	13.1		21.6
50. B.t.u. per lb. of dry coal	B.t.u.	13740	13140	13260		11300
51. Proximate Analysis of Fly Ash from Back Chamber:						
a. Moisture	%	0.2		0.4		0.0
b. Volatile matter	%	1.4		2.8		
c. Fixed carbon	%	78.1		71.3		
d. Ash	%	20.3		25.5		73.8
52. B.t.u. per lb. of dry fly ash from back chamber	B.t.u.	11840		10620		
53. Analysis of Dry Ash and Refuse from Stoker Grates:						
a. Combustible	%	14.7	14.5	Est. 18	16.7	7.1
b. Ash	%	85.3	85.5	" 82	83.3	92.9

Item No.	Unit	11	12	13							
1. Test No.		11	12	13							
2. Remarks		Bureau of Mines tests - uniform load		Veteran's Administration test fairly uniform load	Bureau of Mines tests: Steam jets not used				Steam jets used		
3. Date		Sept.10,1936	Sept.11,1936	Mar.29,1935	March 1937						
4. Duration	hrs.	10.06	6.03	8							
5. Type of boiler		Cross Drum Water Tube		H.R.T.	Cross Drum Water Tube						
6. Type of baffling		Horizontal			Vertical						
7. Grate surface	sq.ft.	42.0		25	52.5						
8. Type of fuel	coal	Subbituminous 2/N		Lignite screenings	Bituminous 5/8" slack						
9. Boiler heating surface	sq.ft.	2040			2510						
10. Ratio of heating surface to grate surface		48.6			47.8						
11. Setting height	ft.	11'-2"		9'-5"	9'-5"						
12. Combustion space volume (approximate)	cu.ft.	600		320	410						
13. Heat release (approximate)	B.t.u./cu.ft./hr.	16400	24900	16300	24000		18000		33000	24000	32000
14. Smoke by Ringelmann chart (approximate average)		1.0	1.3		0.8	1.8	0.5	1.0	1.8	0.6	0.7
Average Pressures and Temperatures:											
15. Steam pressure by gage	lbs./sq.in.	141.1	140.9	115.8							
16. Force of draft - combustion chamber	"H_2O	-0.048	-0.105	-0.055							
- boiler setting ahead of damper	"H_2O	-0.095	-0.233	-0.095							
16a Pressure of air at stoker grates - left side	"H_2O			0.44							
- right side	"H_2O	0.86	0.41	0.44							
17. Temperature of feed water entering boiler	°F.	65.9	65.7	64.9							
18. " " calorimeter	°F.	296.9	295.6								
19. " " escaping gases leaving boiler	°F.	507	572	485							
20. " " boiler room	°F.	72.9	77.9	67							
Quality of Steam:											
21. Percentage of moisture in steam	%	0.27	0.34								
22. Factor of correction for quality of steam		0.99799	0.99787								
Total Quantities:											
23. Total weight of coal as fired	lbs.	9091	8231	5138							
24. Percentage of moisture in coal as fired	%	13.3	13.3	32.1							
25. Total weight of dry coal	lbs.	7882	7136	3490							
26. " " " ash and refuse from stoker grates	lbs.	590	553								
26a " " " fly ash from back chamber	lbs.	47	150								
27. Percentage of ash and refuse from grates based on dry coal	%	7.5	7.7								
27a " " fly ash from back chamber " " " "	%	0.6	2.1								
28. Total weight of feed water	lbs.	62519	55157	25800							
29. " water evaporated corrected for steam quality	lbs.	62393	55017								
30. Factor of evaporation		1.1954	1.1956	1.172							
31. Total equivalent evaporation from and at 212°	lbs.	74585	65778	30018							
32. Percentage of steam used by jets based on steam produced (approximate)	%										
Hourly Quantities and Rates:											
33. Dry coal per hour	lbs.	783	1183	487							
34. " " " sq.ft. of grate surface per hour	lbs.	18.6	28.2	19.5							
35. Equivalent evaporation from and at 212° per hour	lbs.	7414	10904	3752							
36. " " " per sq.ft. of boiler heating surface	lbs.	3.63	5.35								
Capacity:											
37. Rated boiler horsepower	hp.	204	204	73							
38. Boiler horsepower developed	hp.	214.9	316.2	109	90	90	65	65	125	90	170
39. Percentage of rated capacity developed	%	105.3	155.0	149							
Economy:											
40. Water fed per lb. of coal as fired	lbs.	6.88	6.70								
41. " evaporated per lb. of dry coal	lbs.	7.98	7.71								
42. Units of evaporation per lb. of coal as fired	lbs.	8.20	7.99								
43. " " " " " dry coal	lbs.	5.46	9.22								
44. Analysis of Dry Gases by Volume:											
a. Carbon dioxide (CO_2)	%	11.18	11.77	17.63	9.0	10.9	9.6	10.8	14.4	14.4	14.5
b. Oxygen (O_2)	%	8.09	7.34								
c. Carbon monoxide (CO)	%	0.32	0.07		0.0	0.0	0.0	0.0	0.0	0.0	0.0
d. Nitrogen (N_2) by difference	%	80.61	80.82								
45. Lbs. of dry flue gases per lb. of carbon	lbs.	22.21	21.24								
46. " " " " " " dry coal	lbs.	15.50	14.85								
47. Proximate Analysis of Coal as Fired:											
a. Moisture	%	13.3	13.3	32.1							
b. Volatile matter	%	34.0	33.7	28.2			35				
c. Fixed carbon	%	43.9	44.7	31.3							
d. Ash	%	8.8	8.3	8.4							
48. Ash softening temperature	°F.	2200	2310	Approx. 2200			2400				
49. Ultimate Analysis of Dry Coal:											
a. Carbon	%	70.7	71.0								
b. Hydrogen	%	5.2	5.3								
c. Oxygen	%	11.7	12.0								
d. Nitrogen	%	1.2	1.2								
e. Sulphur	%	1.1	0.9								
f. Ash	%	10.1	9.6								
50. B.t.u. per lb. of dry coal	B.t.u.	12570	12650	10660							
51. Proximate Analysis of Fly Ash from Back Chamber:											
a. Moisture	%	0.0	0.0								
b. Volatile matter	%										
c. Fixed carbon	%										
d. Ash	%	90.9	71.0								
52. B.t.u. per lb. of dry fly ash from back chamber	B.t.u.										
53. Analysis of Dry Ash and Refuse from Stoker Grates:											
a. Combustible	%	7.9	6.0								
b. Ash	%	92.1	94.0								

54. Heat Balance Based on Dry Coal:

Item	1 B.t.u.	1 %	2 B.t.u.	2 %	3 B.t.u.	3 %	4 B.t.u.	4 %	5 B.t.u.	5 %	6 B.t.u.	6 %
a. Heat absorbed by boiler	8286	60.6	8353	61.3	9217	66.2	9867	69.8		65.1	10522	76.6
b. Loss due to heat carried away by steam in flue gases	403	2.9	473	3.5	543	3.9	565	4.0			608	4.4
c. " " " " " " dry flue gases	2873	21.0	2446	17.9	2853	20.5	2345	16.6			1068	7.8
d. " " " carbon monoxide	0	0.0	0	0.0	0	0.0	0	0.0			61	0.5
e. " " " combustible in ash and refuse from stoker grates	1333	9.8	1180	8.7	515	3.7	296	2.1			197	1.4
f. " " " combustible in total fly ash going over bridgewall (approximate)	Included in e and g										635	4.6
g. " " " unconsumed hydrogen, hydrocarbons, to radiation and unaccounted for	775	5.7	1178	8.6	792	5.7	1057	7.5			649	4.7
h. Total (see item 50)	13670	100.0	13630	100.0	13920	100.0	14130	100.0			13740	100.0

Item	7 B.t.u.	7 %	8 B.t.u.	8 %	9 B.t.u.	9 %	10 B.t.u.	10 %	11 B.t.u.	11 %	12 B.t.u.	12 %	13 B.t.u.	13 %
a. Heat absorbed by boiler	9036	68.8	8300	62.6				75.7	9181	73.0	8943	70.7		70.1
b. Loss due to heat carried away by steam in flue gases	600	4.6	642	4.8					775	6.2	802	6.4		
c. " " " " " " dry flue gases	1902	14.5	2008	15.1					1615	12.8	1761	13.9		
d. " " " carbon monoxide	25	0.2	251	1.9					75	0.6	42	0.3		
e. " " " combustible in ash and refuse from stoker grates	251	1.9	260	2.0					87	0.7	67	0.5		
f. " " " combustible in total fly ash going over bridgewall (approximate)	593	4.5	1114	8.4					39	0.3	98	0.8		
g. " " " unconsumed hydrogen, hydrocarbons, to radiation and unaccounted for	733	5.5	685	5.2					798	6.4	937	7.4		
h. Total (see item 50)	13140	100.0	13260	100.0					12570	100.0	12650	100.0		

led to studies of proper furnace designs and sizes together with heat releases, admission of overfire air, and use of steam jets. Where the prevention of smoke is an important feature for a given installation, matured, extremely conservative, and not merely optimistic engineering decisions must obtain. Anthracite and semianthracite coals will give no trouble from smoke, but all bituminous and lower-rank coals may do so. For these coals, the author prefers space for a flame travel of at least 14 ft, and such flame travel to be horizontally across the grate if possible.

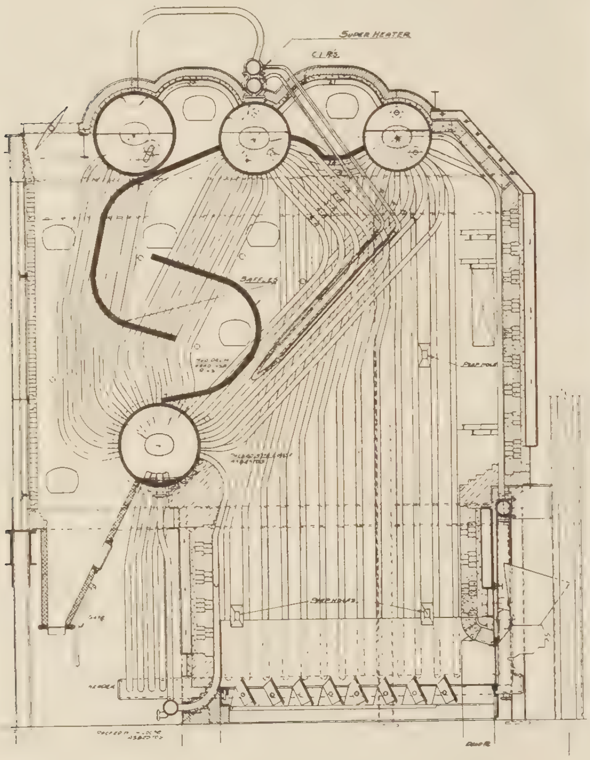


Fig. 2 Underthrow Spreader Stoker With Dumping Grate on a 1000-Hp Four-Drum Bent-Tube Boiler—the Grate Depth Is Approximately 11 Ft. The Ash-Hopper Arrangement Is Not Shown

Heat releases from about 20,000 to 35,000 Btu per hr per cu ft of furnace volume usually are used. On one test, a heat release of over 100,000 Btu was obtained but made much smoke. Furnace temperatures not over 2400 F ordinarily are desirable. The amount of water cooling to be used on the larger installations can be figured much the same as for other types of fuel-burning equipment, taking into consideration the CO_2 to be carried and the fusion temperature of the ash. The temperature of the furnace has a bearing on the possibilities of the slagging of the boiler tubes. Much study has been given to the admission of overfire air. It may serve for metal-cooling purposes, and aid coal distribution as well as combustion. Where furnace conditions are poor, considerable improvement in smoke emission may be obtained by the use of steam jets or air jets properly set in the furnace. A cross fire from jets at the front corners of the setting, aimed somewhat downward toward the rear of the grate, is quite effective in decreasing smoke. Some test results of steam jets are given in Table 1. Proper engineering is bringing forth better types of installations that are meeting smoke ordinances, as well as other types of fuel-burning equipment using bituminous coal or oil.

Fly-ash problems also came to the front with this stoker. Throwing fine coal up into space to be burned gives fine ash particles a good start on a flight with the products of combustion. With vertical baffles, fly ash that with horizontal baffles would have dropped behind the bridge wall went on into the boiler passes. The amount of fly ash depends not only on the load, and the total amount of ash, but also on the type of coal. Although anthracite and semibituminous coals give more ash carry-over than some of the lower-rank coals having some 10

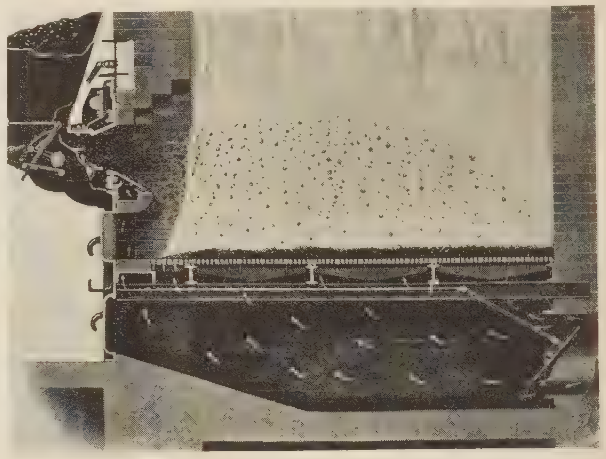


Fig. 3 Overthrow Spreader Stoker With Paddles Revolving So As to Throw the Coal at the Top Point of the Revolution

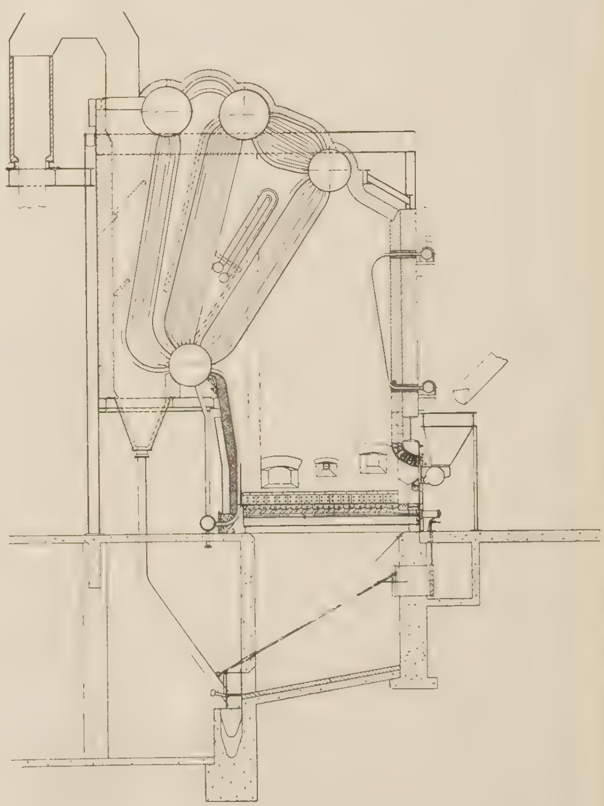


Fig. 4 Overthrow Spreader Stoker With Dumping Grate on a 1000-Hp Four-Drum Bent-Tube Boiler—the Grate Depth Is Approximately 11 Ft

per cent inherent moisture, it cannot always be judged exactly what relative carry-over may be expected for some particular coal. Where there is excessive fly ash, collecting-hopper arrangements may be provided in back chambers and passes in the boiler; some well-designed installations provide an ejector that returns the fly ash from a boiler pass back to the combustion chamber. This arrangement helps burn out any carbon content. Simple forms of baffle-type cinder catchers may be installed in breechings. It is necessary to dump these hopper arrangements regularly. Fly ash should not be permitted to accumulate too much in any one spot, such as along the bottom of the breeching, because it may suddenly lift all at once and go out the stack, creating considerable nuisance. Cinder-catching types of induced-draft fans are applicable. Some fly ash will also usually accumulate at the base of the stack. Keeping all passages clean is a great help in eliminating the fly-ash nuisance. One fireman remarked he would rather take loose sand-like fly ash from behind the bridge wall than fight with clinkered ash in front of the bridge wall. The combustible content of the fly ash may be practically zero for cases where it may subsequently burn out, as in the back chamber of a horizontal-return-tubular boiler; at the other extreme, it has been found as high as 85 per cent for cases where there was little aftercombustion, as at the bottom of the second pass of a vertically baffled boiler. More real attention is now being paid to fly-ash emission from all types of forced-draft fuel-burning equipment. Many of the recently designed government plants are using baffle-type cinder catchers. Some test measurements of fly-ash amounts and combustible content are given in Table 1.

In carrying out the general principles of this stoker, various methods have appeared for throwing or spreading the coal. These methods may best be described by referring to Figs. 2 and 8. Fig. 2 shows an installation of a paddle-type underthrow spreader stoker in which the paddles revolve so as to throw the coal into the furnace at the bottom point of the revolution. The underthrow-type stoker is shown in more detail in Fig. 1. Figs. 3 and 4 give similar views of a paddle-type overthrow spreader stoker in which the paddles revolve so as to throw the coal into the furnace at the top point of the revolution. Fig. 5 shows an installation of a spreader stoker in which the spreading is done with an air jet, the coal being conveyed by air from some convenient location point of the coal hopper and fan. Fig. 6 shows a method of spreading the coal with steam-air jets, the coal being brought from the hopper to the jet with an adjustable screw feed. Mention at this point might also be made of a jet type of coal throw used on locomotive stokers. Development work has been done in adapting this particular type of jet for stationary work, using either air or steam. Figs. 7 and 8, from *Steam Engineer*, London, show a form of application developed in Germany at the Stinnes collieries in the Essen district. This development resulted from a desire to eliminate the grinding of coal in pulverized-fuel-burning systems. It is interesting to note the following quotation, in regard to this system, taken from the *Steam Engineer:*[3]

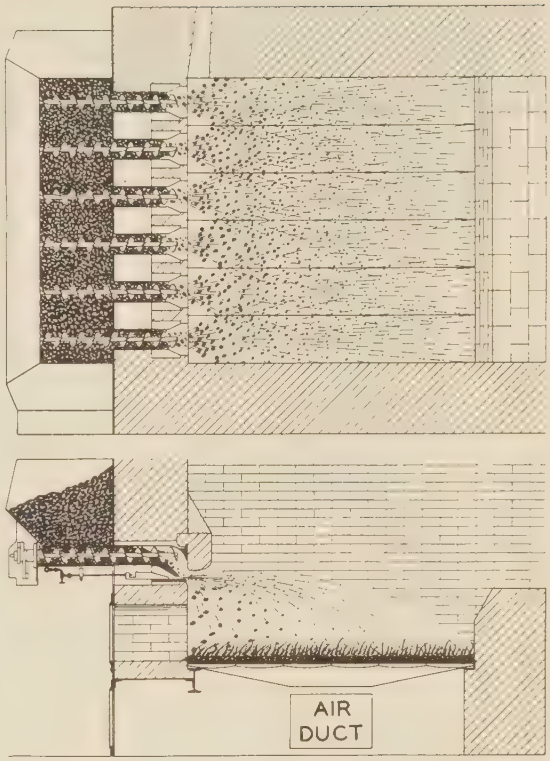


Fig. 6 Spreader Stoker in Which the Coal Is Spread by Steam-Air Jets

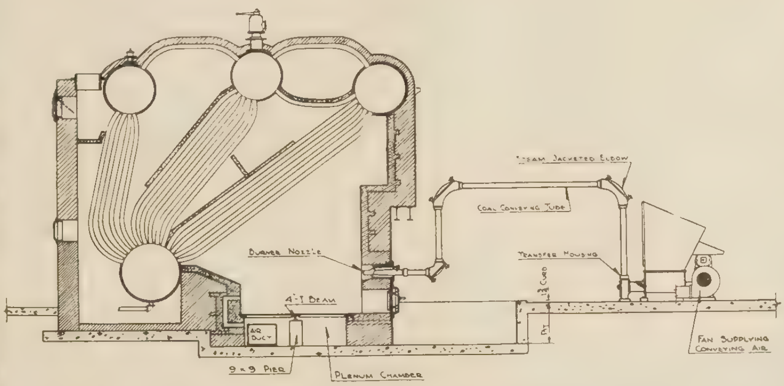


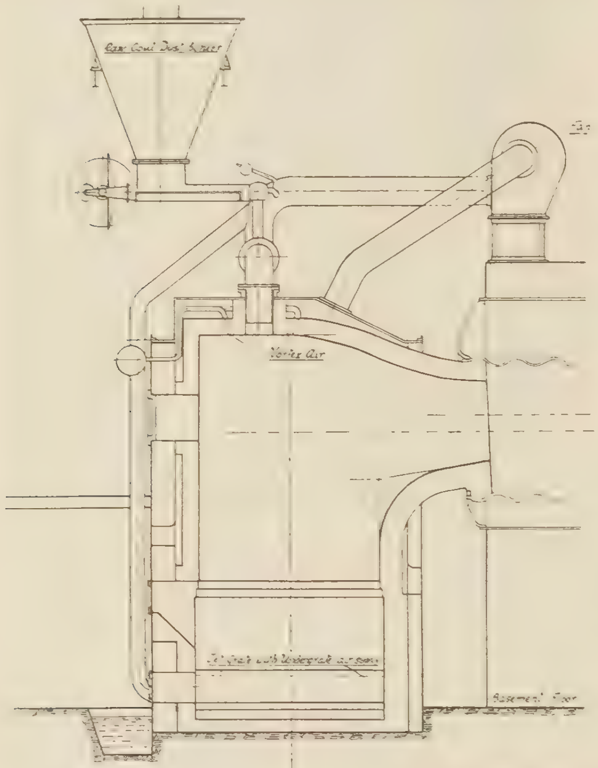
Fig. 5 Spreader Stoker in Which the Coal Is Spread by an Air Jet

"The smaller and lighter grades of fuel are consumed in suspension, and the heavier particles which have been partly burned in the combustion zone descend to the bottom of the furnace, which is composed of slabs of refractory material in which air channels and orifice jets are provided . . . . . Owing to the granulating effect of the secondary air from the jets the ash can be readily blown out or raked out . . . . Doubtless operating engineers will be interested to know that the ash residue in this type of furnace does not give any trouble, having regard to the great difficulties which have had to be overcome in developing the orthodox pulverised-fuel fired furnaces to assure ease of ash handling with maximum efficiency of combustion."

The early type of on-and-off control, although still desirable for some installations, in general soon gave way to continuous types of control. The stoker, with its small amount of fuel on the grate, was found to be quite sensitive to changes of adjustments. It was a relatively simple problem to carry out principles of control which had reached a high state of development on other types of fuel-burning equipment. As before mentioned,

[3] "Dust Coal Burned in Suspension Without Pulverizing," *Steam Engineer*, vol. 1, August, 1932, p. 474.

in the spreader stoker the thickness of ash on the grate continually increases from cleaning to cleaning. Control devices have appeared for the purpose of compensating for the slight increase in draft loss resulting therefrom. One type uses what might be described as an auxiliary or secondary control that maintains a constant volume of air from the fan through the fuel bed for every main fuel-air setting. This secondary control may be actuated by the drop in pressure across an orifice in the main air duct or by any differential pressure that varies with the total air flow. In this type, the boiler damper operates directly from the pressure in the combustion chamber and is independent of the remaining controls. Another simpler type for this purpose eliminates the auxiliary control by means of the old familiar method of operating the boiler damper direct from the steam-line pressure, the forced-draft fan operating from the pressure in the combustion chamber. With any of these controls, some hand adjustment may be necessary when the size of the coal changes appreciably during operation. On the paddle-type stokers it is also quite customary to provide hand control for the speed of the paddles, which affects the spreading.



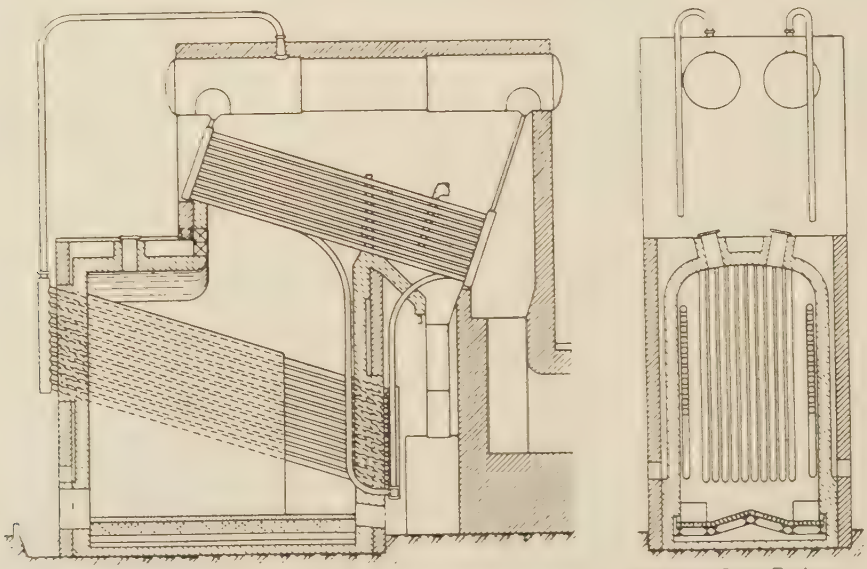
Courtesy of Steam Engineer

Fig. 7 German Spreader Stoker in Which the Coal Is Blown Into the Furnace by Air

It is frequently desirable to have a smoke indicator of some type so that the operator may know what is being emitted from the stack or from each boiler. This may be a simple mirror, or periscope, or one of the more highly developed indicators. One type can be set to show when a chosen "haze" in products of combustion is maintained; when the gases become too lean with excess air, a bulb of one color is lighted; when there is a lack of air, a bulb of another color is lighted. This serves very well as a combustion indicator. Some types ring a bell or blow a horn when the smoke reaches a chosen maximum.

As a general statement, the spreader stoker will show on test about the same overall boiler efficiency as an underfeed stoker, with the exception of the carbon loss in the fly ash. On installations that provide for the burning out of this carbon, such difference would practically disappear. The author recalls watching one installation that was automatically controlled by the two-pen system and arranged to return the fly ash periodically into the combustion chamber. At the time the fly ash was returned, the coal feed cut down. The foregoing comparison of test efficiencies is made where a coal is being burned that the underfeed can readily handle. On the poorer coals, the spreader stoker is at a distinct advantage. Under regular operating conditions, it has been found on our installations that in general the firemen will more nearly approach test efficiencies with the spreader stoker than with the underfeed stoker.

The data in Table 1 giving the results of tests of paddle-type



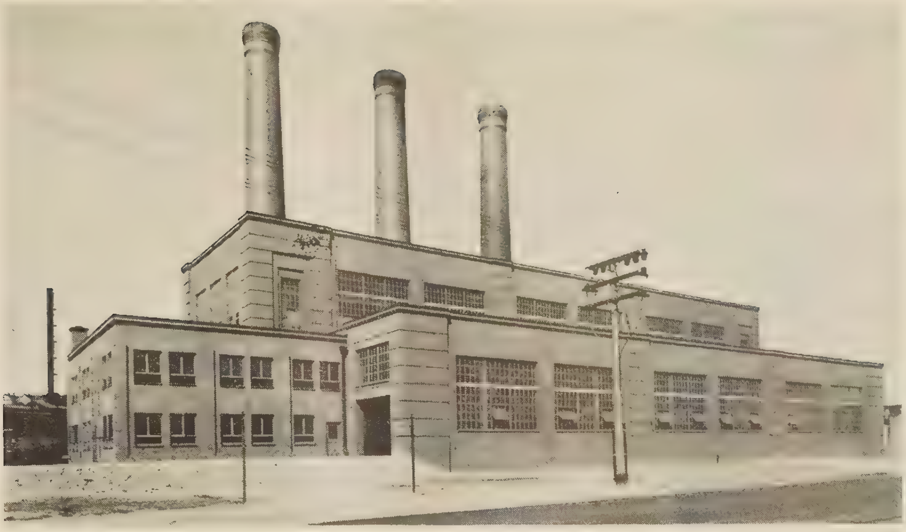
Courtesy of Steam Engineer

Fig. 8 German Spreader Stoker Installed on a 750-Hp Water-Tube Boiler

stokers were chosen largely from the standpoint of the use of different coals. Considerable test data have accumulated by this time, the government having at present about 50 plants equipped with spreader stokers. These tests, with the exception of those marked Veteran's Administration, were run by L. R. Burdick, a member of the A.S.M.E., and the author. Like all such data, the tests are quite individualistic and do not necessarily show the best or the worst that the stoker might do under different conditions, but indicate what happened under a given set of conditions. Tests 1 and 2 give data on the use of anthracite buckwheat. At one government plant, this fuel is giving the lowest total operating costs, even with rather low boiler efficiency. Somewhat better results are obtained with anthracite buckwheat by feeding intermittently instead of continuously. This approaches the ordinary way of hand-firing such fuel. Some hand work on the fuel bed is needed occasionally. The liveliness of the burning of the anthracite, somewhat expressed by the volatile content, has a decided effect on its use in this stoker. In test 2 better stoker action from the general combustion standpoint was obtained with an 8 per cent volatile anthracite than with the 5 per cent volatile anthracite used in test 1. Less handwork was necessary. Test 4 shows the same boiler and stoker when a 22.7 per cent volatile bituminous coal was used. Test 5 shows the use of a high-ash semianthracite which is being used continuously at one government plant. The stoker action is good, but, due to the high ash, the cleaning periods must be quite frequent. Tests, 6, 7, 8, 9, and 10 show the use of higher volatile bituminous coals. Approximate smoke-reading averages are included for tests 6, 7, 8, and 9. Tests 7, 8, and 9 have high heat releases. The boiler setting was too low on this installation. Tests 11 and 12 show the use of sub-bituminous coal, and test 13 shows the use of lignite. Both of the plants at which the tests were made are using these fuels continuously.

There are also added some specific data in Table 1 on the effect of cross-fire steam jets on the CO_2 obtainable, smoke emission, and approximate heat releases. These data were taken on a boiler set too low, and much improvement was obtained by the use of the jets. Another example of a case might be given where it was possible to carry about twice the boiler rating, or an increase in the heat release from about 20,000 to 40,000 Btu, by the use of jets and maintain less than a No. 1 Ringelmann smoke.

As to what the future may bring forth in the use of the stoker or the application of the principles involved, it can only be stated that it appears at present to be in a very active stage of its development. It has successfully replaced a number of both single- and multiple-retort underfeed stokers at various plants and also some chain-grate stokers. It is reaching toward the field of the large boilers. Its limitations in this respect are not so very apparent. It would be interesting to see the results of studies of its application in this field similar in nature and extent to past studies of other types of fuel-burning equipment.



Incinerator Plant, Cleveland, Ohio

Incinerators—Municipal, Industrial, and Domestic

By H. S. Hersey,[1] Cleveland, Ohio

The author reviews briefly the historical development of incinerator plants and discusses the trends in design in this country and abroad. Although industrial-waste incineration is mentioned briefly, and the incineration of domestic and institutional wastes is discussed in some detail, the greater part of the paper is devoted to the incineration of municipal wastes. Many problems and conditions governing steam production in incinerator plants are touched upon, together with general rules for estimating required incinerator-plant capacity in American communities. The author discusses in detail the design of municipal plants with complementary or auxiliary equipment employed. The latter part of the paper is devoted to the utilization of garbage and rubbish as fuel, with examples pertaining to furnace heat balance and furnace temperature.

In the process of the growth of the art of incineration, as related to such wastes as ashes, rubbish, and garbage, it has been recognized that garbage disposal involved problems so baffling that the disposal of ashes and rubbish became of secondary importance. Many methods of treatment and disposal of garbage have been tried, but few have been found that satisfactorily fulfill the requirements for thoroughly sanitary disposal of this noxious waste.

It is the author's purpose to confine discussions in this paper to incineration, as applied to the disposal of the previously mentioned classes of waste in municipal, industrial, and domestic fields; but as the greatest importance attaches to the municipal field, and the investment therein is by far the greatest, it will naturally receive major consideration.

INCINERATION OF DOMESTIC AND INSTITUTIONAL WASTES

Domestic and institutional incinerators cover the requirements for disposing of combustible waste in apartment houses, residences, hotels, hospitals, schools, and the like. For the most part, these installations handle both garbage and rubbish. The principal operating problems involve the maintenance of sufficiently high temperatures to insure against the discharge of obnoxious odors from the chimney, and the control of dust to prevent its being emitted to the atmosphere. There are two types generally considered of standard construction, one of which is manufactured of steel and cast-iron parts. The other type is that built with refractory linings, to which almost invariably gas burners are attached to insure high-temperature operation.

[1] Vice-President and General Manager, the C. O. Bartlett & Snow Company. Mr. Hersey attended McGill University and obtained his early mechanical training in the plant of Pillow & Hersey Manufacturing Company, Montreal, where he later became head of the department for manufacture of railroad-track bolts, nuts, and spikes. Later he entered the employ of the Dodge Manufacturing Company of Canada, Limited, as sales engineer, advancing to the position of manager at Montreal. He became associated with the C. O. Bartlett & Snow Company in 1912, first as its Canadian representative, but went to Cleveland in 1915 where he since has been actively engaged.

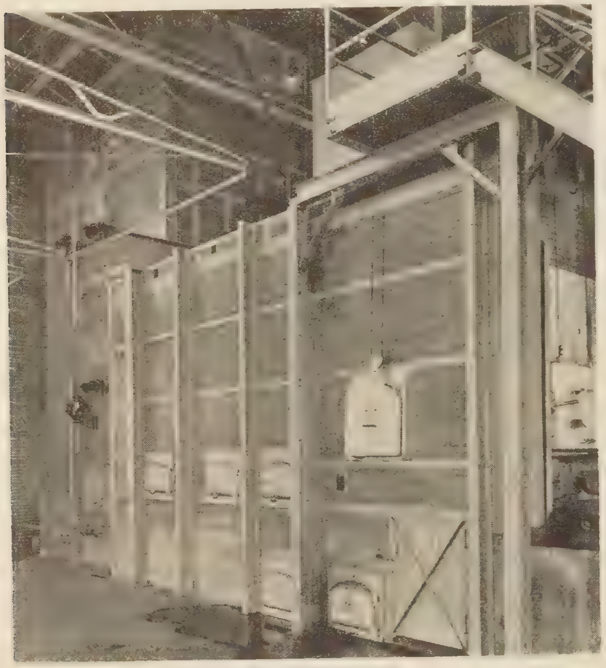
Contributed by the Fuels Division for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until July 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

The design, proportions, and general construction of these units are not greatly dissimilar to the practice employed in the municipal field.

Apartment-house incinerators are most frequently installed in the basement with the necessary vertical flue or chimney passing up through the building, which serves frequently as a chute for passing refuse to the incinerator from the various floors



FURNACE AND WASTE-HEAT BOILER IN INDUSTRIAL INCINERATOR PLANT

of the building. These chutes are fitted with necessary hopper doors at each floor level so that the refuse can be deposited therein by the tenants of the building.

Referring especially to domestic incinerators, unless accessory equipment, such as oil or gas burners, is employed to raise the temperature of the gases to a point where they will be completely oxidized and made nuisance-free, noxious odors are produced in the burning of garbage and any similar materials. Incinerators as usually installed by the general contractor, are of conventional construction, with a straight drop of the household waste into the furnace, with flue area, hopper-door openings, grate area, furnace setting, and wall thickness, governed by fire underwriters as to minimum size, but otherwise lacking in design and construction necessary to safeguard against either odors or dust.

Improvements now offered include hopper doors with dash-pot checks to prevent slamming. In their design care must be taken that they will not get out of order or retard the door closure to such a degree that under certain infrequent conditions there may develop a flash-back of chimney gases into the face of the person operating the hopper door. The firing door in the basement is most frequently interlocked with a check damper to prevent violent air inrush, and there is usually employed a rough control of secondary air over the fire by means of hand-operated louvers and an expansion chamber located on the roof to aid in trapping the dust. Unless great care is exercised, or secondary firing in the combustion chamber is employed, such trouble is to be expected, frequently resulting in the operation of this type of incinerator after dark to avoid detection.

This type of incinerator is open to improvement from the design viewpoint, but as it is sold almost on a pound basis, such improvement would undoubtedly contribute considerably to an increased cost, making it difficult to market it competitively. The indicated corrective would be for local health authorities to establish certain standards, otherwise there is not much hope for improvement over the present conventional designs.

INDUSTRIAL-WASTE INCINERATION

In an effort to keep abreast of the general movement for greater cleanliness and sanitation, industrialists are increasingly attacking the problems connected with a proper disposal of the accumulating wastes which result from their operations. These wastes are of widely different character, varying with the industry or product, and ranging from materials of high inflammability like photographic films and other light waste having high fuel content, to the other extreme of materials having high moisture content, such as wet wood bark resulting from paper-mill operations.

Many of these wastes have been successfully disposed of by incineration, but owing to the wide variations in characteristics, it has been required that incinerators be so designed as to adapt them to the particular duty.

While the woodworking industries have quite generally made profitable use and satisfactory disposal of their wastes by burning them under boilers, in many other industries, having burnable wastes and boilers, there are many factors that have to be considered before determinations can be made as to the advisability of making disposal through burning under boilers or through the employment of specially designed incinerators. All these problems, coupled with the necessity for making such disposal nuisance-free, call for an engineering service from those qualified by experience and a thorough knowledge of the art.

Incinerators in this field are occasionally charged from the top, but the more general practice is to charge the material to the furnace through the side doors, and without the use of mechanical chargers.

When incinerators are employed in banks, and other financial institutions, and are used for the destroying of papers which at one time were valuable, such as bonds and the like, extra care must be taken to insure that none of such papers are carried by the high-velocity gases and discharged from the chimney.

Industrial incinerators require individual study as, for example, when the material to be burned is such as film waste, with the attendant likelihood of explosions and the further necessity of recovering silver salts from the film ash. In some installations, there is also the problem of burning miscellaneous factory waste.

It is important in all such incinerators to have as large combustion chambers as practical, with a free opening beyond the primary fire and a negative pressure assured so that ample air will be drawn in to maintain an oxidizing condition for deodorizing. Such installations, of course, are not usually made without natural-draft gas burners or oil burners for this purpose. When handling highly combustible and lightweight material, difficulty is experienced in trapping the ash, even with combustion chambers of relatively large volume. In some instances, it might be found necessary to introduce a water spray or wet-type dust collector to insure a dust-free discharge from the chimney.

An interesting industrial incinerator with waste-heat boiler has recently been put into operation for burning materials having heating value up to 16,000 Btu per lb. Between 3 and 4 lb of steam is produced per pound of refuse burned, at rates varying from 16,000 to 22,000 lb per hr, and delivered to the steam headers of the main plant for processing work. The waste-heat plant operates 24 hr per day, but the steam production is only pos-

sible for three periods of approximately 6 hr each, as fire cleaning is required taking 2 hr three times per day. The plant is complete in itself including building, furnace, boiler, chimney, and auxiliary equipment.

To return to the major subject of this paper, and in order that we may have an understanding of comparative values in methods and equipment at present employed in refuse incineration, a little history of developments in the art seems in order.

To English engineers, municipal and sanitary officials, the greatest credit is due for the earlier developments in incineration. Like all important developments, they had their small beginnings. However, the studies made of these early applications produced data for further dealing with the involved problems by such men as Horsfalls, Meldrum, and Heenan who respectively contributed much to the development of the first incinerator furnaces, based on sound engineering principles, and in the year 1874, as shown by available records, the first such municipal incinerator for the destruction of mixed refuse was installed in Nottingham, England. This was followed two years later by a similar improved plant at Manchester. In America, the records seem to indicate that the first application of incineration was made in 1885 at Governor's Island, N. Y. This was a development made by an officer of the United States Army. The first American municipal plant was built in Allegheny City, Pa., during the same year.

As would be expected, the applications made in England and the benefits resulting therefrom were carried to the Continent, and eventually to this country. However, the first American designers failed to grasp the problems involved, and apparently were not informed of the technique being developed in England, and they merely attempted to burn wet garbage with the aid of coal or wood instead of mixing combustible rubbish and household ashes with the garbage.

In the early American installations, the general scheme of design was a brick chamber with a garbage-drying grate placed above a primary fuel-burning grate. A wet mass of garbage was gradually dried out by the burning of coal or wood on the primary grate, using natural draft, the volatiles in the garbage being distilled off in this manner, and the fixed carbon more or less consumed. The whole operation proceeded at low temperatures and slow burning rates. The net results were large volumes of highly offensive chimney gases and heavy auxiliary-fuel costs; and to cap the climax, violent protests from the suffering communities, all of which did not react favorably to those active in municipal affairs. Various modifications of design were used, such as a primary fuel grate from which the products of combustion passed over the mass of garbage, which was supported on a drying hearth at a slightly higher elevation than the primary grate, the gases finally passing into a gas-consuming chamber which also had grates for burning auxiliary fuel. In this gas chamber, the temperatures were supposed to be raised sufficiently to eliminate objectionable chimney odors. The results obtained in all of these early designs were unsatisfactory and quite generally the same.

Rapid obsolescence and maintenance of the earlier types of plants proved so high as to make incineration an expensive operation, as it is reported that for approximately 25 years following the installation made in 1885 on Governor's Island the plants built were operated with only indifferent success, and in many cases flat failure. These early plants are stated by one authority to have been about 180 in number, of which 102 were abandoned on account of expensive operation or insufferable nuisance to the community.

The first real recognition given to the high-temperature type of furnaces in this country was about 1906, when an installation was made at Staten Island, N. Y., built to burn a mixture of garbage, rubbish, and ashes. It is doubtful, however, if the engineers who designed or selected this type of plant fully realized that the character of English mixed refuse and American mixed refuse differed so radically in characteristics; however, their first attempt in this country demonstrated the fuel value of a mixed collection.

In about the same year at Westmount, Quebec, Canada, there were installed Meldrum type furnaces, together with boiler installation and electric generators. Later, Heenan furnaces of approximately equal size were added, together with additional boilers and electric generators. This plant was designed and prepared under specifications of the eminent power-plant engineers, Messrs. Ross and Holgate of Montreal, and their interest, as well as that of the community, kept it in efficient operation until about four years ago, when it was decided to accept the rate of a local electric-power company for furnishing electric current to the householders, as well as for street lighting in Westmount, continuing only the incinerating operation.

Following the Staten Island and Westmount plants, others were built in Vancouver, B. C., Seattle, Milwaukee and Buffalo, all of these being equipped with waste-heat boilers. American builders continued to approach the problem with very much the same thought in mind as the English, namely, that of employing the heat value of a combined collection of garbage, ashes, and rubbish in order to produce high temperatures to oxidize the products of combustion, employing, in this connection, large and properly proportioned combustion chambers, wherein the gases were held and mixed at high temperatures until there was complete oxidation of combustible elements, and employing for the travel of the gases ducts of such area as to slow down the velocities of gases to a point where the entrained dust particles would be deposited, which, together with necessary baffles and traps, proved to be practical of application for the minimizing of odors and dust.

The so-called mutually assistant cell type of furnace appeared in England about 1893 and has influenced both British and American design ever since. This type of furnace will be described more in detail later in this discussion. Incinerator design and construction in the United States and Canada, during the past twenty years (as hereinafter set forth), has shown development from early English practice, to better adapt incinerators to American conditions as related to the composition of materials to be incinerated, and as well the methods of collection, but with a tendency to adhere to the fundamental principles of the English practice.

In England, the general practice still favors a combined collection wherein ashes as well as garbage and rubbish are placed in the same vehicle, and so transported to the disposal plant. In America, the general practice is to collect the ashes separately, disposing of them by dumping; and if the garbage and rubbish are to be disposed of by incineration, their collection and transportation to the plant are made together. If, however, as still obtains in some cities, the garbage is disposed of by a reduction system, then these wastes are collected separately, and the rubbish is either (1) incinerated, or (2) dumped and used as fill, frequently with covering of earth. By far the most general procedure, however, is to collect and dispose of the garbage and rubbish together; and, when containing ashes in an amount not exceeding approximately 5 per cent, this combination is readily disposed of by incineration.

Several of the Pacific Coast cities, including San Francisco, still dispose of garbage and rubbish by the fill-and-cover method.

Aside from what has just been stated about the differences in collection methods, the refuse (garbage and rubbish) in America compared with that of England carries more waste matter from the table and shops, of vegetable and animal origin, and further

there is a greater quantity of combustible material consisting of paper, cartons, wood, and the like, resulting from the greater number of newspapers in circulation, and also the use of combustible materials in the packaging of our products, all tending to produce a high calorific value.

In England and certain continental countries, with refuse high in ash content, the tendency in incinerator practice has been to employ screening and other classifying equipment for the removal of fines, inert material, metals and glassware, and the production of a better fuel. With this high-calorific material, and through the employment of boiler-plant equipment in connection with the incinerator, they have steam for a by-product, and frequently find use for the clinker in the production of concrete aggregate and clinker asphalt.

In this country and Canada, rarely has it been attempted to make incinerator operation revenue producing, either through the reclamation of salable materials, such as metals, rags, bones, and the like, or through the production of steam or electric energy, although methods and equipment have been developed and employed in a few instances for accomplishing these results.

The economy of the American method of disposal has been partially predicated upon the savings accomplished through low hauling costs by locating the plants near the centers of production areas and also by substituting the mixed collection service for the former separate collection system.

Because many engineers inspecting modern high-temperature incinerators, not employing boilers or electric-energy units, have a feeling that something should be done to utilize the heat and power so generated, it might be well to deal with some of the factors confronting the engineering and other municipal authorities, in selecting the type incinerator to be used and in judging of the economic values to be expected from the production of steam and electric energy.

In connection with municipally operated plants contemplating steam- and electric-power production, it will be found that one or more of the following four conditions may obtain, and operate to discourage the introduction of such utilization features, and to confine the operations to refuse destruction, with attention concentrated upon sanitation and minimum cost:

1 Difficulty encountered in making advantageous use of steam or current at or near the incinerator site. And even where such uses are found, the demand for either steam or current or both, is such as can with difficulty be supplied for peak or even average requirements, because of:

2 Lack of uniformity as to quality and dependability as to quantity of the refuse, due to variations in production, either seasonal or resulting from extremes of cold and wet weather.

3 Greatly increased capital investment required for a steam- and electric-generating incinerator, as compared with one designed solely for use as a destructor of refuse.

4 The presence of a utility company, holding a franchise from the municipality for the generation, sale, and distribution of steam and/or electric current, with the opposition to be expected therefrom to competition from the municipality.

With the foregoing general observations, and relying upon the general acceptance of the principle that the first and the controlling consideration of a disposal plant should be that of sanitation, the author will leave further details of steam and power development to a later part of this paper and will proceed to a discussion of the conditions generally obtaining, and the practices currently accepted and approved for meeting them.

The wastes which municipalities deal with through collection and disposal are garbage, ashes, rubbish, street sweepings, night soil, and dead animals. The author is assuming that the composition and characteristics of each of these wastes are generally recognized, and that detailed descriptions of them are not at this time necessary. We are concerned at present only with garbage and rubbish and with their disposal by incineration.

For economical incineration, it is required that the rubbish be in sufficient quantity to furnish the necessary heat units for the combustion of the garbage. If there is not sufficient of this available, then the necessary heat units must be supplied by the use of coal or other fuel.

Rules of thumb have been developed for roughly determining quantities of garbage and rubbish produced in the average American city, among which are the following:

There are 200 lb of garbage per capita per year, or a total annual tonnage equal to 10 per cent of the population. Another rule for figuring the garbage production is $^1/_2$ lb per capita per day; but it is the author's judgment that this latter is somewhat lower than prevails, especially in the North.

The quantity of rubbish produced varies more widely than garbage, but a fair average for American conditions is to figure rubbish at about 50 per cent of the garbage tonnage. Allowance, however, must be made for the presence in rubbish of about 10 per cent of noncombustible material. In some communities, records are kept which indicate higher-tonnage rubbish collections, but in these cases it is fair to assume the collections include a higher percentage of such materials as metals, miscellaneous junk, old stoves, bed springs, and the like.

Capacity Required for Refuse-Incineration Plants

In determining the size of incinerators required to dispose of a city's refuse, care should be taken to insure that adequate capacity is incorporated into the plant, or that provisions are made for additions thereto, so that as the city develops and the production of refuse increases, future quantities may readily be disposed of without any very great additional capital expenditure. Further, it is necessary, in determining the plant size, to be sure that provision is made for taking care of peak loads, for, as is well known, there are seasonal variations in the production of both garbage and combustible materials. Sometimes, in cities, where expositions are held or other unusual activities take place, there is such an increase in waste production as to require considerable oversize of plant to take care of this added burden.

Therefore, a fair rule to follow, for the determination of the proper size of refuse-incinerator plant, would be to divide the population by 1000, which would give the size of plant in tons per 24 hr adequate to take care of the needs of a city, including peak seasonal garbage production and make some provision for future additional population. For example, a community of 100,000 people should construct an incinerator having a rated capacity of 100 tons for a period of 24 hours. This will provide for the peak garbage production in the late summer and fall and also allow about $33^1/_3$ per cent excess capacity for future increase in population.

Costs of Disposal by Incineration

The costs of operating an incinerator plant, where sufficient rubbish is available, and where air preheaters are used as part of the equipment, will be free of any charge for auxiliary fuel, providing the characteristics of the mixed refuse conform to those of refuse as collected in the average American city, namely, garbage by weight 65 per cent, combustible rubbish by weight 35 per cent, and having an average combined moisture content approximating 50 per cent. This proportion of garbage and combustible rubbish can be collected in the average city if proper ordinances are passed and enforced. Other costs should include capital cost, depreciation, maintenance, amortization, labor, power, water, and the like.

It would be useless to set forth in a paper of this sort even an average cost taken from the records available, as the variation is so great as to be misleading. No doubt a great deal of the discrepancy is attributable to the variations in cost-accounting and reporting methods of the various cities. In certain cases, records are kept by department employees who are not interested in their correctness, and in other cases the reports reflect the prejudice of the department keeping these records, or even the influence of the incinerator manufacturers. Labor costs in one section of the country compared with others—especially of plants operating in the South with those in the North—alone account for great discrepancies in the cost of disposal. It is therefore necessary that any per-ton cost advanced by a municipality or incinerator manufacturer should be given thorough analysis before accepting it for the purpose of comparison with costs in other cities.

In order to support this statement as to cost, it is interesting to note that the Civic Development Department of the Chamber of Commerce of the United States in 1931 made a survey of refuse disposal in 154 American cities which showed average cost of disposal by incineration of $1.26 per ton; however, this is practically meaningless inasmuch as the reports analyzed showed variations ranging from 23 cents per ton to $4.25 per ton. Obviously when the difference in the operating cost is so great, the figures are not comparable.

It may be of further interest to note the direct comparison of operating costs between incinerator plants of like rated capacity, under the same controlling supervision; one where the refuse is placed in the charging containers by manual labor, the other plant employing refuse-receiving pits from which the material is raised and placed in crane charging hoppers directly over charging containers. In this connection are mentioned the Wellington incinerator at Toronto, Canada, and the Symes Road destructor of the same city. The former is manually charged, and the latter crane-operated. Both plants have a capacity rating of 400 tons per 24 hr.

Wellington Plant (manually charged):	
Labor cost	$1.40 per ton
Total cost	1.60 per ton
Symes Road Plant (crane-operated):	
Labor cost	$0.83 per ton
Total cost	0.92 per ton

These results are from the published report of operations of the Department of Street Cleaning of the City of Toronto for the year 1936.

Modern Incinerator Plants

In order to present a general description of the arrangement and equipment of a modern incinerator plant, the author gives descriptions of the major units of typical plants, and of their functions.

Weigh Scales. It is usual to employ weigh scales at the entrance to the plant, whereby loaded collection vehicles passing over them are weighed and the records tabulated. In the case of smaller cities, this is not employed as it is an added expense, and the weigh clerk and office requirements have to be provided.

Receiving Pits. In a plant using cranes for the rehandling of the mixed refuse, there is provided a receiving pit into which the collection vehicles dump the mixed refuse. In plants designed for 24-hr furnace operation, the capacity of the receiving pits must be large enough to store mixed refuse for at least 16 hr operation of the furnaces, since the collection deliveries are usually made within a period of 8 hr. The plants having receiving pits for the mixed refuse require that the grab-bucket cranes handle the material from the receiving pit to charging hoppers over the furnaces for final introduction into the furnace chamber.

Storage Floors. Many plants not employing the receiving pit are provided with a ramp to a dumping floor which is at an elevation above the storage and charging floor. With such an arrangement, the mixed refuse is fed by hand to the charging holes or charging machines of the furnace chambers. Some storage floors are provided with service cranes to assist hand feeding. The same storage capacity, namely for 16 hr operation, is required in this type of plant in order that the furnaces may operate for 24 hr.

Hillside Sites. Plants are sometimes located on hillside sites, permitting vehicles to drive in off the main thoroughfare without the use of a ramp; and in some instances they are found advantageous due to lower expense for roadways compared with the ramp and other construction details.

Direct-to-Furnace Plants. In smaller plants, it is frequently the case that the collection vehicle drives directly into the building on the charging floor and the refuse is dumped directly into the charging holes of the furnace chamber. In plants designed in this manner, the furnace capacity should be large enough to keep up with the rate of delivery of mixed refuse. These plants are seldom operated continuously during 24 hr.

Salvage Plants. A few plants in this country employ facilities such as picking belts with magnetic pulleys for the purpose of picking off paper and rags, and for the removing of ferrous metals. In such cases, the picking is done by hand labor, and it is necessary to provide bailing equipment for the bailing of tin cans and papers.

Charging Hoppers. In plants with receiving pits and grab-bucket cranes, the mixed refuse, as previously stated, is deposited by the grab bucket into charging hoppers. These charging hoppers are on a charging floor directly over the furnace chambers. Each hopper is divided into sections and each section is open into the top of the charging container of the charging machine, which is directly below the charging floor and over the top of the furnace chamber.

INCINERATOR FURNACES AND ACCESSORY FUNCTIONING UNITS

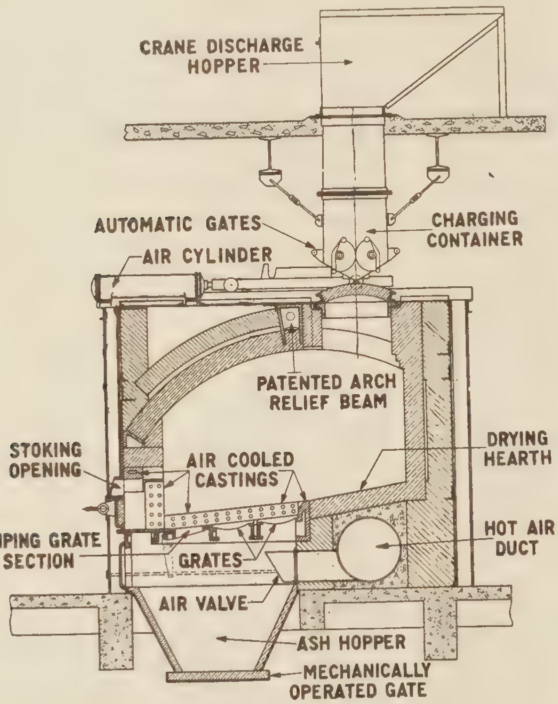
In all types of incinerator-furnace construction now offered by reputable manufacturers, there is one principle common to all, namely, that charges of wet material do not drop directly onto the burning grates, but are retained on drying grates, drying hearths, or in drying baskets until the contained moisture is sufficiently evaporated to make the refuse burnable, after which it is drawn onto the burning grate.

The furnace chamber is that part of the incinerator structure which encloses the burning grates and drying hearth, or drying grates or basket. A number of incinerator manufacturers build furnace chambers after the English design of mutually assistant cells; that is, the burning grates are divided into cells by the installation of castings approximating 8 in. in height above the grate level. Typical of this design is a furnace having four cells so divided off by castings, all enclosed in a refractory-lined chamber with an ash pit for each cell placed below the grate level, and with provision for admitting forced-draft air to each cell, separately controllable. On the stoking side of the furnace chamber there is a guillotine-type door for each cell provided with an opening therein, through which the stoking of the fires and partial cleaning of the grates is accomplished. The guillotine doors are raised for finally cleaning the grates following the burning down period. The refractory lining of the furnace chamber is provided with proper insulation. Steel plating and the necessary buckstays form the outside construction of the furnace chamber. The drying hearths are usually of refractory construction, built

with a slight slope toward the burning grates. Drying hearths sometimes are constructed as drying grates of stationary cast-iron grate sections in lieu of refractories.

In the mutually assistant-cell type of furnace, each cell has a charging opening in the main arch, through which the charges of mixed refuse drop by gravity onto the drying hearth. In cases where material is delivered into the furnaces directly from collection equipment, it is usual that the charging openings are extended to the charging-floor level and are closed with a refractory-lined charging-hole cover.

In the larger plants, where material is handled to the furnaces by cranes from receiving pits, or fed by hand from storage floors, charging machines are provided, one for each cell. These charging machines consist of a refuse-charging container with hopper bottom or sliding gates, having a charging carriage with



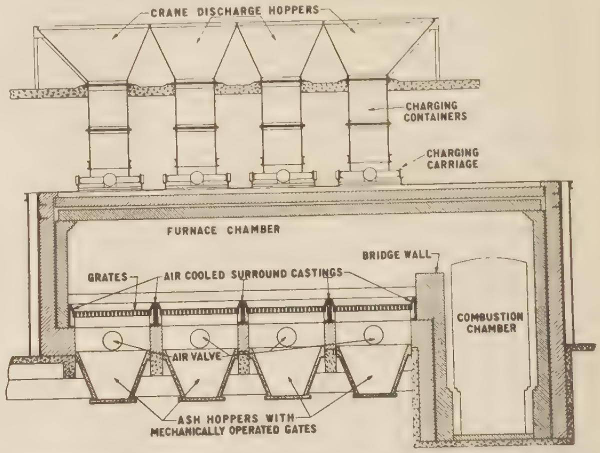
Cross Section of Incinerator Furnace Chamber

rollers operating on structural-steel supports and rails. The carriage is actuated either by a compressed-air ram, or an electric motor, or by hand-operated mechanism.

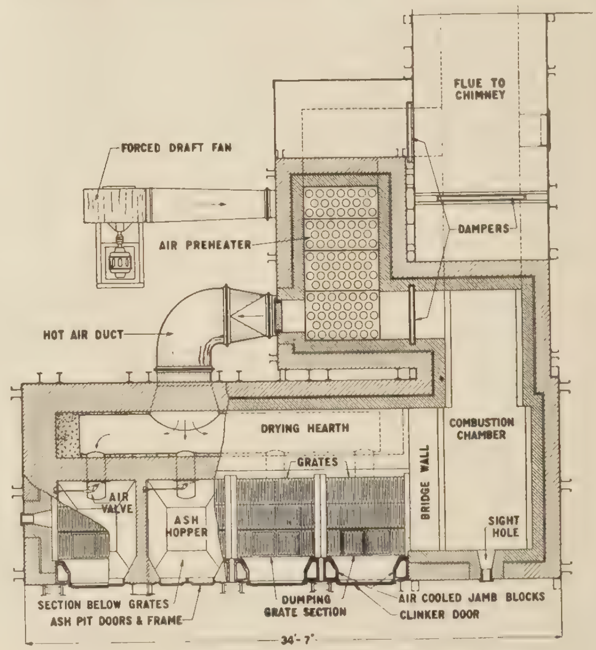
The actuating mechanism of the carriage is under the control of the stoker, and the charging-hole cover, which is refractory-lined, opens or shuts with the travel of the carriage, allowing the charge of refuse to fall by gravity out of the charging container through the charging hole and onto the drying hearth in the furnace chamber below. Upon the closing of the charging opening, the charging container can be refilled with refuse by the cranes or charging-floor man, and is again ready for further operation by the stoker when, in his judgment, the fire requires another charge.

The advantage claimed for the mutually assistant-cell type of furnace chamber is that draft control and fire control are individual and separate for each cell; that fires can be cleaned, one cell at a time, while normal burning rates and temperature on all other cells are maintained during this operation. Further, that if it so happens fires are in bad condition in one or more of the cells, then the fires in the others will assist in reestablishing in such cell or cells the proper burning rates and temperature.

Some types of furnace chambers do not employ the mutually assistant-cell principle, and in some cases these are provided with drying hearths or drying grates on which the refuse is retained until such time as the greater part of the moisture has



Longitudinal Sections of Furnace and Combustion Chambers



Plan of Mutually Assistant Furnace

(Four-cell, mutually assistant-incinerator furnace and combustion chambers showing drying-hearth grates, ash hoppers, flues, preheaters, and fan, with air ducts and draft control.)

been driven out. Usually these furnace chambers are also refractory-lined, and they may be either rectangular or circular in construction. They are most frequently charged from the top and rarely have more than two charging holes per furnace chamber, and sometimes only one.

A type of furnace-chamber construction not refractory-lined has been installed in many cities. This is built of boiler plate with water legs and crown sheet, somewhat like a locomotive-boiler furnace. The refuse is retained directly above the burning

grates in tubular water-cooled baskets until properly dry, and stoked down as required. One or two charging holes are generally provided for each chamber in this type of furnace.

Furnace-chamber volumes usually run from 9 to 10 cu ft per ton of furnace capacity per 24 hr. Burning rates range from 70 to 85 lb of mixed refuse per sq ft of burning grate per hr, this being normal capacity. Overload rates of 100 lb per sq ft per hr can be maintained for indefinite periods. The rates referred to are all based on the use of forced draft.

Combustion Chambers

Combustion chambers are refractory-lined and are placed either back of, or at the end of the furnace chambers. The purpose of a combustion chamber is twofold:

1 To provide a means of finally mixing the products of combustion generated in the furnace chambers with available oxygen, thereby effecting complete combustion at high temperature.

2 To provide a space of ample volume and area so that the gas velocities will be sufficiently lowered to deposit fly ash, dust, and solids.

In practice, a minimum temperature of 1250 F and maximum temperature of 2000 F, with an average not less than 1450 F, is required for the combustion chambers to operate satisfactorily. Under these conditions it will be found that all products of combustion are completely oxidized, and the gases discharged from the furnace chimney will be absolutely inoffensive.

To accomplish the proper mixing of gases and to insure the deposit of fly ash, dust, and solids, it is usual to construct the combustion chambers having volumes ranging from 12 to 15 cu ft per ton of 24-hr rate of incinerator capacity, with such cross sections of the combustion chambers as to limit the gas velocities to 15 fps.

Heat release in combined volume of furnace chambers and combustion chambers is from 10,000 to 15,000 Btu per cu ft per hr.

Flues

Flues as used for the passage of gases from the combustion chambers are refractory-lined, and in practice require cross-sectional areas large enough to limit gas velocities to 25 or 30 feet per second.

Air Preheaters

In burning refuse, rapid ignition is of great importance to secure capacity and maintain temperature; further, as there is a large amount of moisture required to be evaporated and refuse to be heated to the point of ignition, preheated air is of unquestionable value. It is a well-known fact that oxygen in the air will unite with carbon more readily when either or both are preheated. In refuse furnaces, combustible material is heated on the drying hearth by radiant heat from the furnace walls and arches and by radiation and convection from the fuel bed itself, and the air is heated by means of a preheater, using for this purpose such portion of the gases from the combustion chamber as in the judgment of the operator is required to meet any condition within the furnace. The proper use of preheated air will make refuse combustible that would not otherwise burn without additional fuel. Furthermore, since preheated air occupies a larger volume per pound than air at room temperature, it follows that a given weight of preheated air is distributed more advantageously throughout the combustibles in the furnace, resulting in less total air required for combustion, which reflects in higher furnace temperatures.

Construction of preheaters varies according to the temperature of flue gases required to be passed through them. For example, in a plant not having waste-heat boilers, or where the products of combustion pass through the preheater prior to the boiler setting, the temperatures of the gases passing through the preheater are quite high. On the other hand, if set after a waste-heat boiler, any conventional type of preheater for boiler service may be used. Preheaters set without boiler or ahead of boilers must be of a high-temperature type, preferably vertical tubular down-draft, with hot gases passing inside the tubes from top to bottom. It is usual that the forced draft make at least two passes through the preheater on the outside of the tubes. Heat-exchange surfaces are encased in steel boxes in order to minimize or prevent leakage.

Preheated-air temperatures in practice usually range from 300 F to 400 F, and in order to proportion preheaters so that these temperatures may readily be attained, exchange surfaces will be found to run from 7 to 8 sq ft per ton of furnace capacity per 24 hr. A preheater proportioned in this manner can usually develop the required temperature by passing 40 per cent or less of the total products of combustion through the preheater, set without or ahead of waste-heat boilers.

On account of the importance attached to preheated air as related to the heat balance of the furnace, especially in the burning of very wet refuse, further consideration on this point is given later in this paper.

To the best of the author's knowledge, the first application of preheated air to a refuse plant not employing steam-generating units was in connection with the installation made in Toronto, Canada, in 1915 at the Don incinerator; and because of this application, patents were applied for and issued, covering a design wherein the gases from the combustion chamber passed downward through the tubes.

Expansion Chambers

Expansion chambers are refractory-lined structures designed to reduce the final velocities of gases prior to passing to the chimneys so as to precipitate any dust, fly ash, or other solids that may have escaped the combustion chambers. Expansion-chamber volumes in practice range from 10 to 14 cu ft per ton of rated furnace capacity per 24 hr. Cross-sectional areas should be such as to reduce gas velocities to 10 fps.

The first application of expansion chambers which came to the author's attention was the installation made in 1931 at Montreal, Canada.

Chimneys

Incinerator chimneys must be capable of handling gases up to 1000 F, which temperature sometimes prevails at the base of the stack when burning mixed refuse. In burning highly combustible rubbish, chimney temperatures may be expected to be as high as 1800 F, and therefore, for rubbish incineration, should be lined and otherwise constructed so as to withstand this condition and function continuously.

Chimneys to serve incinerators are customarily built of an outer radial brick shell, with refractory lining throughout the entire height of the chimney column. The more general practice, in relation to such linings, is that they be independent of the column and completely self-supporting. Experience has developed a practice whereby the linings are corseted with steel straps, both belted and vertically disposed, and so arranged as to be interconnected, all for the purpose of insuring against failure.

The first application of such a corset, coming to the author's attention as applying to incinerator installations, is the Wellington Incinerator at Toronto, Canada. Chimney areas will usually be found in practice to equal 20 to 25 per cent of the burning-grate area served, and the heights will run from 100 to 175 ft.

Dampers

Dampers are regularly furnished and installed to control the

flow of gases in the main exit flue from the combustion chamber, the entrance flue to the preheater and the exit flue from the preheater (when preheaters are set ahead of boilers), and occasionally in the main flue connecting the expansion chamber to the chimney. These dampers are subjected to quite severe duty, are necessarily built to withstand high temperatures, and are most frequently constructed with special high-temperature alloy castings with refractory surfaces in the path of travel of the high-temperature gases. Occasionally they are of water-cooled design, but more infrequently of all alloy, high-temperature, or special ferrous material. Generally, they are of the guillotine type, counterbalanced and/or winch-operated.

When control dampers are used in connection with preheaters which are set behind waste-heat boilers, they need not be constructed to withstand high temperatures. When waste-heat boilers are used, high-temperature dampers are generally installed in the flue entrance to the boiler.

Ash-Handling Equipment

In the smaller plants, ashes and clinkers are generally raked off the stationary grates onto the firing floor and later shoveled into wheelbarrows and spoiled outside the incinerator building. In the larger plants, ash and clinkers are passed through dumping grates within the furnace chamber directly into ash hoppers located directly underneath the grates, and the quenching of the ashes takes place within such hoppers.

Ash hoppers are usually accessible by means of ash basements which permit of trucks driving directly through the plant underneath the respective hoppers; or if industrial cars are used, the contents of the hoppers are either taken to a remote point by the cars to be used as fill, or discharged into push-button-controlled ash-skip hoists or onto platform elevators, and by these means raised and discharged into ash bins or other receptacles, generally outside the building, from whence the ashes are transported for final disposal at convenient intervals.

Furnace Auxiliaries

Auxiliary machinery generally includes, in the large-size plants, electric traveling cranes with grab buckets, forced-draft fans, air compressors, and temperature and draft instruments. Crane capacities are generally $3^1/_2$ to 5 tons, employing grab buckets having capacities of $1^1/_2$ to 2 cu yd. Forced-draft fans should be capable of supplying as much as 5 lb of air per lb of mixed refuse burned, and are usually direct-connected to an electric motor. Air compressors generally must supply not less than 10 cfm of actual free air per charging machine served.

Temperature-control instruments, including recording and indicating pyrometers, are usually installed for observing combustion-chamber, preheated air and chimney temperatures, and draft gages for determining the forced and chimney draft. The use of control instruments has, in many instances, been unnecessarily elaborate, the essentials being only indicating pyrometers for registering combustion-chamber and preheated-air temperatures.

In small plants, and where close supervision prevails, operations can be successfully carried on without any instruments.

Stoking and Cleaning Fires

Mechanical stoking of incinerator furnaces has not as yet reached a successful solution. A man on the cool end of a stoking tool is still the accepted means of moving material onto the burning grate and spreading the fire. Manual labor is also employed for fire cleaning, although the efforts attached to this task have been lessened in the more recently constructed larger plants equipped with dumping sections within the furnace chamber. These dumping grates discharge ash and clinker to ash hoppers; but even with the apparatus povided, the labor of breaking clinkers on the grates and passing the residue through the dump opening is considerable. In the smaller plants with stationary grates, the clinker is required to be broken by slice bars and is usually raked out by manual labor onto the firing floor or into ash skips. The real reason for the continuation of hand stoking is because of the uncertainty of the quality of the refuse handled, as it is never the same from season to season, or even from one charge to another, varying in heating value, moisture, ash content and mechanical condition.

Steam Production in Incinerator Plants

With further reference to previous discussion in this paper relative to steam production, the author has to state that when the visiting engineers referred to, or other technically trained men, first view a modern incinerator plant not equipped with steam-generating units, and after gazing into this inferno, and noting the large volume and rolling action of the gases at temperatures maybe as high as, possibly, 2000 F in the combustion chamber—all of which is truly impressive—they all ask the same question: "What do you do with all that heat?"

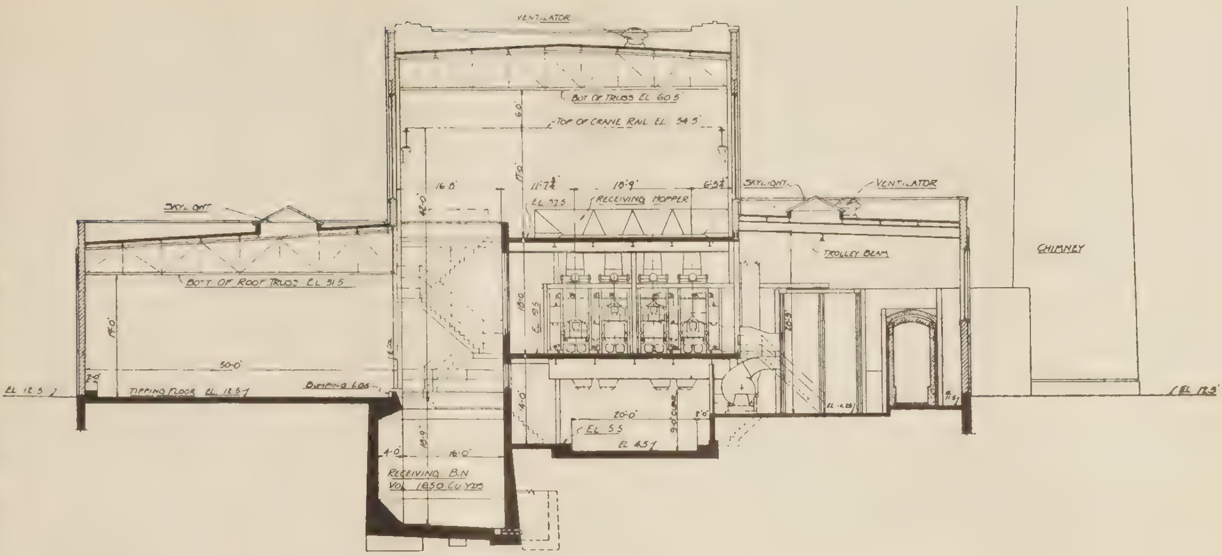
In America, incinerator plants, in which full use is made of the heat developed, are the exception rather than the rule. However, as previously covered, in most of the high-temperature plants there is utilization of some of the heat values by employment of the combustion gases for heating the air for combustion. When our visitors are informed that, except for such auxiliary uses, the tremendous quantity of heat which they have just observed is being wasted up the chimney, with considerable concern they remark on the apparent lack of efficiency, and unless they inquire further into the facts, or are furnished with an explanation of the deterrent factors which enter into the problem, they are apt to classify incinerator practice as a criminal waste of the taxpayers' money.

After complete combustion has been accomplished, there is, of course, no reason why the developed heat cannot be utilized for making steam, as sanitary conditions can be maintained throughout the operation, even though the flue gases would be cooled down by their passage over the heat-absorbing surfaces of the steam boiler, providing, however, that complete oxidation at high temperature has taken place in the combustion chamber before contact is made by the gases with the cooling surfaces in the boiler.

In England, and on the Continent, nearly all the large incinerator plants are equipped with steam boilers and power-plant equipment for the production of electricity, employing the energy for pumping of water, sewage, or other municipal or private power purposes. Compared with Americans, Europeans appear in general more inclined to make use of all possible savings, whether it be in incinerator plants or other operations from which values in the form of by-products may be obtained; and American people are regarded by Europeans as notorious for their apparent wastefulness, not alone in incineration, but with reference to such resources as farms, mines, oil, and water power.

However, the primary purpose of an incinerator plant is to destroy refuse in a sanitary manner, and this must be accomplished every day throughout the year that collection of refuse is made, so that the question of power development is, and, to a great extent should be considered, secondary.

There are a number of steam and power-development incinerator plants in America, some of which have applied the steam to the servicing of municipally owned asphalt plants. Others have been able to sell their steam or power in quantities to public utilities without entering into direct competition with them, while still others use the steam for no other purpose than for the operation of the equipment which is auxiliary to the func-



Typical Cross Section of an Incinerator Plant

tioning of the incinerator furnace. However, the amount of power necessary for the operation of this auxiliary equipment such as forced-draft fans, compressors, and the like, is very small, and in most instances would be cheaper if purchased from a public-service company than when produced by the incinerator, if the cost of extra equipment, labor charges for skilled personnel, maintenance, necessary amortization, and all like charges are included in the cost of production.

Probably the outstanding installation wherein the use of steam is profitably employed is at the rubbish-burning incinerator plant of the City of Rochester, N. Y. It so happens that their incinerator plant is located adjoining their garbage-reduction plant, and in the process of reduction, large quantities of steam are required for the processing; and such steam as is metered to the reduction plant is credited to the operations of the incinerator.

Unique also is this reduction plant, in that it is in close proximity to the plant of the Rochester Gas and Electric Corporation whose steam lines are also connected to the reduction steam mains, so that when steam is required in excess of that produced by the incinerator plant, they are able to procure as much steam as is necessary for covering their peak requirements; and in this manner, fluctuating quantities of rubbish coming to the incinerator, and the varying qualities and conditions of same do not affect continuity of operations in the reduction plant. The existing incinerator plant is inadequate to handle the production of rubbish in Rochester, and a contract has recently been awarded for an additional incinerator plant employing steam-generating units. This may have the effect of producing sufficient steam so that the reduction plant will not be required to purchase steam at any time from the public-service company, except in cases of emergency.

It is important to note that in the design of a steam-producing incinerator plant, there are involved certain difficulties not encountered in the design of a coal-burning boiler plant. In the first place, a coal-burning plant is designed to use a fuel having quite definite characteristics, and of practically uniform chemical constituents, and which can be purchased in any required amount, making it quite easy to meet any definite load or variation of load which may occur during any period of operation. In the case of a steam-production incinerator plant, the designer is limited in his guarantee of the amount of steam to be produced by what he estimates can be produced under the worst conditions of operation, when the refuse may be extremely wet and only a minimum quantity is available. At the same time, he must provide incinerator capacity to meet the requirements for maximum production of refuse. From what has been said about the design of steam-producing plants, it is evident that if the designer is considering a plant to meet a steam demand exceeding the possibilities under the aforesaid adverse conditions, he must provide in his plant means for producing steam by auxiliary coal, oil, or gas firing in separate stand-by boilers, or by incorporating auxiliary grates or burners for such auxiliary fuel in connection with the boilers set in with the incinerator.

Another consideration which must be taken into account is the fluctuation in the steam demand itself, which has no relation to fluctuations in the fuel, and stand-by equipment must be provided to meet rapidly fluctuating demands. Even though the average load may be balanced by the average amount of refuse available for fuel, the designer is likely to be further handicapped because in all probability the minimum of available fuel will sometimes coincide with maximum steam demand.

It is for such reasons as these that designing a steam-producing incinerator plant is not simple; for where a definite capacity must be guaranteed, which is impossible with the minimum quantity of available refuse, a large investment is necessarily required to be made for stand-by equipment.

When the steam demand is small and steady enough so that more steam than is required can be produced at any time by the refuse available, the problem is comparatively simple, as it resolves itself into the selection of a boiler with sufficient heating surface to produce the necessary steam. Inasmuch as under these conditions more flue gas is produced than is necessary for steam production, the economical design would be a boiler only large enough to make the necessary steam, and so set and provided with flues that the excess flue gas produced can be by-passed directly to the chimney. By this arrangement, the necessary furnace capacity can be provided for the maximum collection, and at the same time the boiler will be ample for the steam demand with only a minimum of investment.

If a steam-producing incinerator plant is to be considered, a complete study should be made of all relevant conditions and

problems. As previously indicated, it should be viewed from the standpoint of whether or not the results when accomplished will justify the investment. If this is settled in the affirmative, then the selection of furnace and boiler equipment, together with electric-generating units can be made to meet the conditions. Included in the study must be a careful analysis of the maximum, minimum, and average quantities available, as well as the quality of the refuse to be burned—with particular reference to the fuel value. This latter will involve the determination of the noncombustible and moisture content of the refuse. After these points have been settled and it is decided to proceed with the designing of a steam-power incinerator plant, calculations can be made as to the furnace design to provide the capacity necessary to take care of the maximum collection of refuse, and combustion-chamber temperatures can be predicted within definite limits, as can also the quantity of flue gas available for steam production.

Boiler sizes and design must be suitable for the quantity of flue gas available at the predicted temperature. Boilers are generally of the water-tube type, of various designs and arrangements of baffling. Natural draft or induced draft may be used, according as they lend themselves to the conditions obtaining. Boilers may be set so that one particular boiler operates on one particular incinerator, or they may be set so as to take gas from a main flue which will be a mixture of gases from several incinerators. Preheaters, as usually set in the English practice, take flue gas which has passed through the boiler.

While it is not the purpose of this paper to follow through any one particular problem in design, it must be quite evident that any project must be considered individually, so that the selection of plant equipment and plant arrangement therefore may be suited to and meet all controlling conditions. The one guiding rule, which should be borne in mind by the designer, is that he should balance investment against resulting values.

Obviously, the steam that may be generated by the burning of a pound of refuse varies with the heat value of the material; and while the heat value of the refuse on a dry basis may be nearly constant, weather conditions may cause great differences in the day-to-day evaporation results. Theoretical calculations show that overall efficiency of boiler furnace and grate may vary from a low of 25 per cent to a high of possibly 65 per cent, corresponding to approximately an F & A evaporation of 0.5 lb at 25 per cent efficiency, and approaching 4.5 lb at 65 per cent. Overall efficiency of boiler furnace and grate is expected to be not less than 50 per cent for good practice, but, of course, variations up and down are to be expected, due to changes of the refuse or relative amount of boiler heating surface, etc. The great variation in theoretical figures indicated above is due to the fact that the lower figure is based on refuse of poor quality, and the higher figure on a relatively higher fuel value.

Available data from English practice, when burning refuse such as is usually collected in that country, indicate plant evaporation on the F & A basis ranging from 0.8 to 3 lb of steam per lb of refuse burned. From records of operations at Paris, France, it appears that about 1.1 lb of steam is produced per lb of refuse. Very few data of the results of American practice are available, but such as we have show evaporations ranging from 0.7 to 1.5 lb.

With reference to most of the installations in America for incineration, coupled with steam-power development, it is my belief that a much better showing of evaporative capacity could be made if the gas passages and heating surfaces in the boilers had been made large enough to develop the full possibilities of the plant.

In concluding this part of the discussion, it may be stated that the trend in English and European designs is to incorporate steam-producing equipment in municipal incinerator plants, which indicates an engineering judgment that the resulting economies justify the investment. American conditions, on the other hand, in most cases do not appear to warrant the investment in steam boilers and power-producing equipment, although there are exceptions, as brought out by the author, wherein there were justifying economies.

Mixed Refuse as Fuel

As previously stated, garbage and rubbish as generally produced in American cities, when mixed together as collected, will have sufficient fuel value, and be in such condition that combustion can be supported at temperatures sufficiently high to insure against the emission of objectionable odors from the incinerator chimney. Many studies have been made of garbage and rubbish as fuel, based on proximate or ultimate analyses, and it has been found that the matter of obtaining samples in order to produce a fair average is not an easy one. This, on account of the great variation of the material, even throughout the same truck load of garbage or rubbish and, of course, seasonal variations of garbage are evident, also rainy weather greatly influences the moisture content in the collection.

Probably the most comprehensive study of garbage and rubbish ever made in this country was by the late Major I. S. Osborn, for the District of Columbia in 1914 and 1915. The staff of the U. S. Department of Agriculture, Bureau of Soils, the Department of the Interior, Bureau of Mines, cooperated in this study, making chemical analyses and determinations of moisture, combustible, ash, and Btu value of both garbage and rubbish, and proximate analyses of rubbish alone. The results of these analyses are given in Table 1.

The incinerator designer must meet contract guarantees, the most important of which is the guarantee of an odorless chimney which means, primarily, sufficient temperature in the combustion chamber. The designer in predicting combustion-chamber temperatures based on the fuel he is to handle must realize the uncertainty of anything approaching a uniform fuel, in moisture, combustible, ash, and heat values. The usual method today in taking bids, is to require the bidder to make guarantees based on specified mixtures of garbage and rubbish having a certain specified moisture, combustible, ash, and heat content.

Furnace Temperatures and Auxiliary Fuel Required

It may be of interest to follow through the development of a typical heat-balance formula and show its application to some practical problems. It is recognized that there are certain short cuts and approximations, but the following method has proved sufficiently accurate for general purposes. The nomenclature used in the method for calculating the approximate temperature in the combustion chamber, and the amount of auxiliary fuel required in burning mixed refuse is as follows:

T = temperature in combustion chamber, F
t_a = temperature of air supplied for combustion, F
K = net weight of bone-dry combustible material in refuse as fired, lb
C_k = heat value of bone-dry combustible, Btu per lb
K_c = weight of auxiliary fuel, lb per lb of refuse fired
C_c = heat value of auxiliary fuel, Btu per lb
R = net weight of residue (noncombustible and ash), lb per lb of refuse as fired
W = weight of moisture in refuse, lb per lb of refuse as fired
A = weight of air required for combustion, lb per lb of refuse as fired; this weight must include air for auxiliary fuel, if any
F = weight of dry flue gas, lb per lb of refuse as fired
H_1 = heat required for moisture in refuse

H_2 = heat required for raising dry flue gases from t_a to T
H_3 = heat losses due to radiation, unconsumed, humidity in air, incomplete combustion, hydrogen in fuel, clinkering, and unaccountable
60 F = assumed temperature of room air and refuse
0.25 = specific heat of dry flue gas, Btu per lb per deg F
0.5 = specific heat of water vapor, Btu per lb per deg F

Then for all practical purposes, $H_1 + H_2 + H_3$ = total heat in the fuel. The formulas for H_1, H_2, and H_3 are as follows:

Heat required for moisture in refuse is $W\ (212 - 60) + 970.4W + 0.5W\ (T - 212) = 152W + 970.4W - 106W + 0.5TW$, or

$$H_1 = 1016.4W + 0.5TW \qquad [1]$$

Heat required for raising dry flue gases from t_a to T deg is $0.25\ F\ (T - t_a)$, where $F = A + K + K_c$ (approximately, neglecting ash and moisture in K_c). Then $H_2 = 0.25\ (A + K + K_c)\ (T - t_a)$ or

$$H_2 = 0.25T\ (A + K + K_c) - 0.25t_a\ (A + K + K_c) \qquad [2]$$

Losses due to radiation, unconsumed, humidity in air, incomplete combustion, hydrogen in fuel, clinkering, and unaccountable is assumed to be

$$H_3 = 0.2\ (KC_k + K_c\ C_c) \qquad [3]$$

The sum of H_1, H_2, and H_3 is the total heat in the fuel and is equal to $KC_k + K_cC_c$ or $1016.4W + 0.5TW + 0.25T\ (A + K + K_c) - 0.25t_a\ (A + K + K_c) + 0.2\ (KC_k + K_cC_c) = KC_k + K_cC_c$. Reducing

$$0.25T\ (A + K + K_c) + 0.5TW = 0.8\ (KC_k + K_cC_c) + 0.25t_a\ (A + K + K_c) - 1016.4W$$

or

$$T = \frac{0.8\ (KC_k + K_cC_c) + 0.25t_a\ (A + K + K_c) - 1016.4W}{0.25\ (A + K + K_c) + 0.5W} \qquad [4]$$

As an example of how these formulas can be applied, the au-

TABLE 1 ANALYSIS OF GARBAGE AND RUBBISH

Average analysis of garbage as collected:	
Moisture, per cent	72.0
Combustible, per cent	24.4
Ash, per cent	3.6
Heat value on a wet basis, Btu per lb	2,450
Heat value on a dry basis, Btu per lb	8,775
Heat value on a net dry combustible basis, Btu per lb	10,100
Variations in garbage analysis:	
Highest moisture, per cent	85.05
Lowest moisture, per cent	63.59
Highest combustible, per cent	32.50
Lowest combustible, per cent	12.64
Highest ash, per cent	6.72
Lowest ash, per cent	2.01
Highest heat value on dry basis, Btu per lb, average	10,521
Lowest heat value on dry basis, Btu per lb, average	7,021
Average analysis of rubbish as collected:	
Moisture, per cent	7.50
Combustible, per cent	72.50
Ash and noncombustible, per cent	20.00
Heat value on a dry basis, Btu per lb	5,500
Heat value on a wet basis, Btu per lb, resolved	5,950
Heat value on a net dry combustible basis, Btu per lb, resolved	7,600
Proximate average analysis of garbage:	
Moisture, per cent	72.0
Volatile combustible, per cent	21.0
Fixed carbon, per cent	3.4
Ash and noncombustible, per cent	3.6
Proximate average analysis of rubbish:	
Moisture, per cent	7.5
Volatile combustible, per cent	59.5
Fixed carbon, per cent	13.0
Ash and noncombustible,	20.0

Volatiles for all practical purposes can be considered as methane, CH_4

TABLE 2 GARBAGE SPECIFICATIONS USED IN AUTHOR'S EXAMPLES

Assumed:
Mix to be burned is 65 per cent garbage and 35 per cent rubbish, by weight.
Garbage is 73 per cent moisture, 17 per cent net combustible, and 10 per cent ash and noncombustible.
Rubbish is 10 per cent moisture, 70 per cent net combustible, and 20 per cent ash and noncombustible.

Make-up of mix when fired:	
Water from garbage (0.65 × 0.73 = 0.475), per cent	47.5
Water from rubbish (0.35 × 0.10 = 0.035), per cent	3.5
Total water in mix as fired, per cent	51.0
Net combustible from garbage (0.65 × 0.17 = 0.11), per cent	11.0
Net combustible from rubbish (0.35 × 0.70 = 0.245), per cent	24.5
Total net combustible in mix as fired, per cent	35.5
Ash and noncombustible from garbage (0.65 × 0.10 = 0.065), per cent	6.5
Ash and noncombustible from rubbish (0.35 × 0.20 = 0.07), per cent	7.0
Total ash and noncombustible in mix as fired, per cent	13.5
Summary of mix as fired:	
Water in mix, per cent	51.0
Net combustible in mix, per cent	35.5
Ash and noncombustible in mix, per cent	13.5
Total	100.0
Heat value of mix as fired (8000 × 0.355), Btu per lb	2840

Air required to burn the mix:
The approximate theoretical air for chemical requirements for fuel of this character may be assumed as in the same proportion to air required for coal with a heat value of 14,500 Btu, as the heat value of the mix is to 14,500 Btu, or

$$\frac{\text{Air per lb of mix}}{\text{Air per lb of 14,500-Btu coal}} = \frac{\text{Heat value of mix}}{\text{14,500 Btu of coal}}$$

thor has selected a problem, using as a basis the specifications given in Table 2, which were recently given by one city.

Experience shows that it is possible to operate an incinerator with less than 100 per cent excess air, and that 50 per cent excess is a fair average with refuse of the character under consideration.

Therefore, the approximate theoretical air required to burn the mix as fired is (2840/14,500) × 12 = 2.35 lb, or 3.53 lb at 50 per cent excess, and 4.70 lb at 100 per cent excess. By substituting values in Equation [4] for T using 50 per cent excess air and no auxiliary fuel, with preheated air at 400 F

$$T = \frac{0.8\ (8000 \times 0.355 + 0) + 0.25\ [400\ (3.53 + 0.355)] - (1016.4 \times .51)}{0.25\ (3.53 + 0.355) + (0.5 \times 0.51)}$$

or $T = 1740$ F.

By substituting values in Equation [4] for T using 100 per cent excess air and no auxiliary fuel with preheated air at 400 F

$$T = \frac{0.8\ (8000 \times 0.355 + 0) + 0.25\ [400\ (4.70 + 0.355)] - (1016.4 \times .51)}{0.25\ (4.70 + 0.355) + (0.5 \times 0.51)}$$

or $T = 1485$ F.

It would be quite proper to guarantee an average combustion-chamber temperature of 1450 F in the light of these calculations.

To determine how much coal of 14,000-Btu value will be necessary to burn wet garbage, with no rubbish and no preheated air, and air for combustion being delivered at room temperature of 60 F. Assume that the mix to be burned is garbage and coal (amount of coal to be determined); garbage is 73 per cent moisture, 17 per cent net combustible, and 10 per cent ash and noncombustible; heat value of net combustible in garbage is 8000 Btu per lb; heat value of coal is 14,000 Btu per lb as fired, neglecting moisture and ash in coal; temperature required in combustion chamber is 1500 F; and the air required to burn coal is 18 lb per lb of coal as fired.

Then the theoretical air required to burn garbage is (8000 × 0.17/14,500) × 12 = 1.125 lb air per lb garbage. At 50 per cent excess 1.687 lb air is required. The total air for coal + garbage = $(K_c \times 18) + 1.687$.

Substituting in Equation [4]

$$1500 = \frac{0.8\,(8000 \times 0.17 + K_c \times 14{,}000) + 0.25 \times 60\,(K_c \times 18 + 1.687 + 0.17 + K_c) - 1016.4 \times 0.73}{0.25\,(K_c \times 18 + 1.687 + 0.17 + K_c) + 0.5 \times 0.73}$$

$$= \frac{1088 + 11{,}200K_c + 270K_c + 27.8 + 15K_c - 742}{4.5K_c + 0.464 + 25K_c + 0.365} = \frac{373.8 + 11{,}485K_c}{4.75K_c + 0.829}$$

Hence

$7125K_c + 1243 = 373.8 + 11{,}485K_c$ and $K_c = 0.20$ lb of coal per lb of garbage.

Thus, 400 lb of coal will be required to burn each ton of garbage without preheated air and maintain a combustion-chamber temperature of 1500 F.

Value of Preheated Air. Assuming the same factors for garbage and coal as just given, and by employing preheated air at 400 F, and substituting in Equation [4]

$$1500 = \frac{0.8\,(8000 \times 0.17 + K_c \times 14{,}000) + 0.25 \times 400\,(K_c \times 18 + 1.687 + 0.17 + K_c) - 1016.4 \times 0.73}{0.25\,(K_c \times 18 + 1.687 + 0.17 + K_c) + 0.5 \times 0.73}$$

$$= \frac{1088 + 11{,}200K_c + 1800K_c + 185.7 + 100K_c - 742}{4.5K_c + 0.464 + 0.25K_c + 0.365} = \frac{531.7 + 13{,}100K_c}{4.75K_c + 0.829}$$

Hence

$$7125K_c + 1243 = 531.7 + 13{,}100K_c$$

and

$$K_c = 0.119 \text{ lb of coal per lb of garbage}$$

Thus, 238 lb of coal will be required to burn each ton of garbage, and maintain a combustion-chamber temperature of 1500 F, using preheated air at 400 F.

It is evident that the use of a preheater in this rather extreme case, burning wet garbage with no rubbish, saves the difference between 400 lb and 238 lb, or 162 lb of coal per ton of garbage burned. In other words, this 162 lb of coal is the value of the recovered heat per ton of garbage burned, made possible through the employment of a preheater and heating the air to 400 F not alone as required for combustion of the garbage, but also for the combustion of the coal.

With a preheater there is required 1.687 lb of air per lb of garbage, and $18 \times 0.119 = 2.142$ lb of air for 0.119 lb of coal, or total air per pound of garbage = 3.829 lb. In other words, there is returned to furnace in 3.829 lb of air preheated from 60 F to 400 F, using 0.25 as specific heat of air, $3.829 \times 340 \times 0.25 =$ 325 Btu per lb of garbage, or 650,000 Btu per ton of garbage returned to furnace. This, you will note, is equivalent only to 46.5 lb of 14,000 Btu coal in direct heat value, whereas the actual coal saving indicated is 162 lb per ton of garbage burned. In explanation of this difference it can be readily realized that approximately 70 per cent of the heat liberated in burning the coal under the conditions obtaining goes to raising the dry gases of its own production to 1500 F, and to clinkering and other losses, leaving only 30 per cent for effective work. This is a startling argument in favor of preheated air.

Experience with the heat-balance formulas given by the author has shown that actual operation checks satisfactorily for all practical purposes with the predictions made. The experienced incinerator engineer will use any theoretical formulas that he may develop with judgment and a margin of safety, realizing that his margin of safety may sometimes be the means of his salvation in meeting the contract guarantees.

From what has preceded, the figures disclosed may leave the reader with the impression that it is not possible to burn wet garbage in an incinerator without the aid of auxiliary fuel, or even with the use of preheated air to assist in the burning; however, it will be recalled that the preceding figures have all been based on a heat balance in which the waste gases are discharged at high temperature, reaching the chimney at approximately 1000 F under practical operating conditions. It is possible, however, to destroy wet garbage without the use of any heating values other than those inherent in the combustible material in the garbage itself, and in so doing to maintain combustion-chamber temperatures in excess of 1800 F, which are well above the point required to eliminate any objectionable odors. However, to accomplish this result, and in order to effect combustion of the garbage, it is necessary to condition same by predrying the wet garbage.

The method employed has been completely demonstrated on a commercial scale by employing a rotary garbage drier reducing the wet garbage to 35 or 40 per cent moisture content, and then returning this dried garbage to the dryer furnace, and employing the same as fuel for further drying operations, using the necessary flue gases for this purpose. Not alone in theory, but also in practice, the heat produced by the burning of the dried garbage is considerably in excess of the requirements for drying—so much so that it is necessary to provide a bypass to permit passing the excess gases over and above what are required to do the drying, or the excess garbage fuel may be burned in separate furnaces. A parallel-flow drier is employed for the drying for the reason that the hottest gases come directly in contact with the wettest garbage; and, as the garbage, in its passage toward the discharge end, becomes less moist, the gases in like travel are being reduced in temperature which insures against scorching.

Because of the results thus obtained in these operations in successfully destroying garbage, patents were obtained covering this method; however, to date, no municipality has this method in continuous operation.

In the author's opinion, before many years developments and installations will have been made, employing mechanical charging and stoking of incinerator furnaces, with mechanical aid for ash handling and that these or some such developments will come from the activities of some of those cities now spending so much time in the study of incineration.

Prevailing practice, as related to specifications, requires that bidders make a statement to the effect that they have designed and built incinerators of the type bid upon, which have been in successful operation for at least two years, and are still in satisfactory operation at the time of making the bid. Should this practice be continued in future specifications, it would seem that developments based upon experimental work must come from those cities interested in mechanically operated plants, as any new developments presented by incinerator engineers would probably not be considered, because of the qualifications just mentioned.

Temperature and Combustion Rates in Fuel Beds

By MARTIN A. MAYERS,[1] PITTSBURGH, PA.

Since the classical investigations of Kreisinger, Augustine, and Ovitz (1),[2] on the reactions and temperatures in a fuel bed, there has been increasing interest in this subject, and measurements similar to those reported in their paper have been repeated by several others (2, 3, 4, 5) with different types of fuels. In addition, Nicholls (6) and Nicholls and Eilers (7) have developed recently an experimental method for determining the characteristics of fuels in underfeed combustion. In spite of the interest shown in this subject, there have been no theoretical investigations of the problem, with the result that the experimental results remain, to a large extent, uncoordinated. It is the purpose of this paper to supply a first step toward meeting this deficiency.

THE nomenclature used in this paper is as follows:

c_p = specific heat of air and combustion gases, Btu per lb per deg F
h_1 = heat of combustion of reaction $C + O_2 \rightarrow CO_2$, Btu per lb O_2
h_2 = heat of reaction $C + CO_2 \rightarrow 2\,CO$, Btu per lb CO_2
k = coefficient of thermal conductivity of bed, Btu per ft per hr per deg F
l = depth of fuel bed, ft
p_1 = concentration of oxygen in combustion gases, fraction
p_2 = concentration of carbon dioxide in combustion gases, fraction
p_3 = concentration of carbon monoxide in combustion gases, fraction
x = distance from grates, ft
x_1 = distance of plane of ignition from grates, ft
G = rate of gas flow through fuel bed, lb per sq ft per hr
M = stoichiometric factor = 0.414
P_1 = concentration of oxygen in entering air, fraction
T = temperature elevation of fuel bed above surroundings, deg F
T_1 = temperature elevation of the fuel bed above surroundings at plane of ignition, deg F
T_i = ignition temperature of fuel, deg F
T_a = temperature elevation of air and combustion gases, deg F
U = rate of fuel flow and of combustion in the steady state, lb per sq ft per hr
U_i = rate of advance of plane of ignition (and fuel feed in unrestricted ignition), lb per sq ft per hr
α = coefficient of heat transfer between solids of fuel bed and combustion gases, Btu per cu ft per hr per deg F
β = coefficient of heat transfer from bottom of fuel bed to surroundings, Btu per sq ft per hr per deg F
γ = coefficient of heat transfer from top of fuel bed to surroundings, Btu per sq ft per hr per deg F
μ_1 = specific rate of the reaction $C + O_2 \rightarrow CO_2$, lb per cu ft per hr
μ_2 = specific rate of the reaction $C + CO_2 \rightarrow 2\,CO$, lb per cu ft per hr
ρ = specific heat of the fuel, Btu per lb per deg F

The General Equations

The fundamental concept on which the following considerations are based is that heat flows through a fuel bed in two ways: First, by convection by the air supplied for combustion and the resultant gases; and second, by a process obeying the laws of metallic conduction. The latter process is not limited as to mechanism, although it probably occurs through radiation between adjacent particles. It is sufficient for the present purpose that a property equivalent to thermal conductivity exists for the fuel bed as a whole and that it be measurable (8, 9, 10). This process is—solely in the case of underfeed fuel beds, and partially in overfeed fuel beds—responsible for heating the incoming green fuel up to its ignition temperature.

For the purpose of this discussion, use will be made of a simplified fuel bed such as shown in Fig. 1. The bed is considered to be a continuous solid, of a porous nature such that air can be blown through it. In effect, this focuses attention on the fuel bed as a whole, rather than on the individual pieces of which it is composed. The x-direction is taken as the direction of air (or gas) flow through the bed, usually vertically upward, and the bed extends from zero to l which need not be constant. Variation of the properties of the bed in the x-direction only will be considered; for the present, variations in the planes normal to the x-direction will be neglected. If there is a flow of fuel through the bed, it will be considered positive if in the positive x-direction. Ignition is supposed to take place at some plane designated by $x = x_1$, where x_1 may have any value from zero to l, and combustion takes place from there to the end of the bed, $x = l$. The differential equation for the temperature of the bed may then be stated as

$$\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right) - \frac{\partial}{\partial x}(\rho U T) - \alpha\,(T - T_a) = \frac{\rho}{d}\frac{\partial T}{\partial t} + X(T) - \phi(x, x_1) \quad \ldots\ldots [1]$$

[1] Member of Staff, Coal Research Laboratory, Carnegie Institute of Technology. Jun. A.S.M.E. Mr. Mayers was graduated from Sheffield Scientific School, Yale, in 1927 with degree of B.S. From 1927 until January, 1929, he was employed by the Brooklyn Edison Company as a junior engineer in the test bureau, being stationed most of that time at Hudson Avenue generating station. He then worked for a short period as engineer for the Prat-Daniel Corporation, now of Port Chester, N. Y., erecting and servicing air preheaters and draft-producing equipment. During the scholastic year 1929–1930 he returned to Yale to study for the degree of M.S. in mechanical engineering. On the completion of this course he was employed for six months by Sargent & Lundy, Inc., as assistant research engineer, resigning to take up his present work in December, 1930. In this position he has engaged in fundamental research on the combustion of solid fuels and is the author of several contributions to the technical press on this subject.

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Fuels and Steam Power Division, and presented at the Annual Meeting of The American Society of Mechanical Engineers, held in New York, N. Y., November 30 to December 4, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until July 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

where T represents the temperature of the fuel; T_a that of the air or gas stream; k the thermal conductivity of the bed; ρ the heat capacity of the fuel; U its rate of flow through the bed; d its bulk specific gravity; and α represents the heat-transfer coefficient between fuel and the air stream—it refers to a unit of volume of the bed and contains the surface effective in heat transfer as a factor. The term $X(T)$ represents the heat absorbed in endothermic reactions such as coking or cracking, while ϕ represents the heat liberated by combustion and is given by

$$\phi(x, x_1) = \begin{cases} 0, \text{ when } 0 \leqslant x \leqslant x_1 \\ \mu_1 h_1 p_1 (x, x_1) - \mu_2 h_2 p_2 (x, x_1), \text{ when } x_1 \leqslant x \leqslant l \end{cases} \quad [2]$$

where μ_1 and μ_2 represent the rates of the reactions (A), $C + O_2 \rightarrow CO_2$ and (B), $C + CO_2 \rightarrow 2\,CO$, respectively, at unit concentration of the reacting gases—they also refer to unit volume of the bed just as does α; h_1 and h_2 are the quantities of heat liberated or absorbed in the reactions (A) and (B) referred to unit weight of the reacting gases; and p_1 and p_2 represent the fractional concentrations of O_2 and CO_2, respectively.

In Equation [1] the first term represents the gain of heat by an element of volume due to conduction; the second represents the loss to an element due to the heat carried away by the fuel flowing through it; the third represents the loss due to the transfer of heat from the solid fuel to the air or gas stream; and the fourth represents the heat absorbed in local rise in temperature. Thus the left-hand side of Equation [1] represents the net gain of heat in an element of volume due to transport processes, while the right-hand side represents the net absorption of heat by reaction and by increase of temperature, so that the equation is simply a heat balance.

The temperature of the air stream satisfies the equation

$$Gc_p \frac{\partial T_a}{\partial x} - \alpha(T - T_a) = 0 \ldots\ldots\ldots\ldots\ [3]$$

where G represents the rate of air or gas flow, and c_p is the specific heat of the gas. This equation states that the heat absorbed in raising the temperature of the gas passing through an element of volume is equal to the heat transferred to the gas from the fuel.

The concentrations of the various constituents of the gas stream satisfy the set of equations

$$\left.\begin{aligned} G\frac{\partial p_1}{\partial x} + \mu_1 p_1 &= 0 \\ G\frac{\partial p_2}{\partial x} + \mu_2 p_2 &= \mu_1 p_1 \\ G\frac{\partial p_3}{\partial x} &= 2\,\mu_2 p_2 \end{aligned}\right\} \text{ when } x_1 < x \leqslant l \ldots\ldots [4]$$

where p_3 represents the concentration of CO. The significance of these equations is exemplified by the second, which states that the rate of increase in quantity of CO_2 in the gas stream, given by the term $G(\partial p_2/\partial x)$, plus the rate of loss by reaction to form CO, given by $\mu_2 p_2$, is equal to the rate of formation of CO_2 from O_2, given by the term $\mu_1 p_1$.

It may be noted in passing that in the three-dimensional case the only changes that would appear in these equations are that the first term in Equation [1] would be replaced by the appropriate Laplacian, while the first derivatives with respect to the space coördinate x in Equations [1], [3], and [4] would be replaced by the divergences of the appropriate quantities.

Equations [1] to [4], inclusive, with suitable boundary conditions would be sufficient to determine a general solution for the one-dimensional case, but the mathematical difficulties are great. It is advisable to limit the problem further to secure simplicity in the mathematical treatment.

The Steady State With Pure Underfeed Burning

In the first place it is advantageous to neglect changes in the values of the coefficients in the differential equations due to ash or to changes in position in the bed. In effect, the solid representing the fuel bed will be required to be uniform and isotropic, as well as continuous, which means simply that for α, ρ, k, μ_1, and μ_2 suitable average values must be used. In addition X will be assumed to vanish, and U and G will be assumed constant. Although G actually increases by about 10 per cent during the passage of the gas through the bed, this change can be neglected without vitiating the analysis. The rate of fuel flow U decreases in a real fuel bed by an amount equal to the product of the fraction of the combustible in the fuel and the difference between the initial value of U and the combustion rate, but since its effect on the temperature is important only close to the plane of ignition where it has departed very slightly from its original value, this variation may also be neglected.

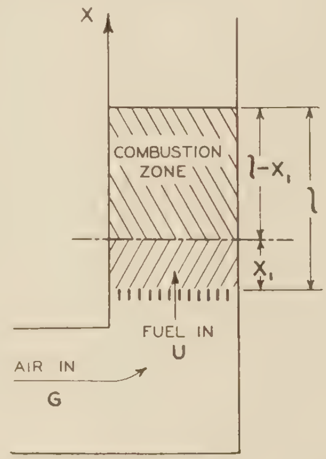


Fig. 1 Representation of Simplified Fuel Bed

The second limitation is on the mechanical system. Let the fuel be charged at the bottom of the bed at the same rate as that at which it is burned. Then the fuel-bed height l will remain constant and a steady state will be reached in which the temperatures and concentrations at any point in the bed do not change with time. The fuel-feeding mechanism is restricted in that it must not interfere with the admission of air over the entire grate surface, so that the combustion proceeds by pure underfeed action, as this term is defined by Nicholls (6, 7). The restriction to the steady state makes it possible to eliminate the term in $\partial T/\partial t$ in Equation [1], and to use ordinary, instead of partial, derivatives throughout, thus markedly simplifying the analysis. Thus, the differential equations become

$$\frac{d^2 T}{dx^2} - \frac{\rho U}{k}\frac{dT}{dx} - \frac{\alpha}{k}(T - T_a) = \begin{cases} 0, \text{ when } 0 \leqslant x \leqslant x_1 \\ -\frac{1}{k}[\mu_1 h_1 p_1 - \mu_2 h_2 p_2], \text{ when } x_1 \leqslant x \leqslant l \end{cases} \ldots [5]$$

$$\frac{dT_a}{dx} - \frac{\alpha}{Gc_p}(T - T_a) = 0, \text{ when } 0 \leqslant x \leqslant l \ldots\ldots\ [6]$$

$$\left.\begin{aligned}&\frac{dp_1}{dx}+\frac{\mu_1}{G}p_1=0\\&\frac{dp_2}{dx}+\frac{\mu_2}{G}p_2=\frac{\mu_1}{G}p_1\\&\frac{dp_3}{dx}=2\frac{\mu_2}{G}p_2\end{aligned}\right\}\text{ when } x_1\leqslant x\leqslant l\ldots\ldots[7]$$

In setting up the boundary conditions, the ambient temperature may be taken as zero, and the calculated values of T will then be the elevations in temperature above that of the surroundings. The fuel bed loses heat from both its top and bottom surfaces by radiation to the surroundings at rates that will be assumed proportional to the respective temperature elevations. This assumption is not strictly correct since the heat transfer by radiation varies as the difference of the fourth powers of the absolute temperatures, but this error may be compensated by choosing the heat-transfer coefficient appropriate to the temperature (11). Then the boundary conditions on T become

$$\left.\begin{aligned}&\frac{dT}{dx}-\frac{\beta+\rho U}{k}T=0,\quad \text{at } x=0\\&\frac{dT}{dx}+\frac{\gamma}{k}T=0,\quad \text{at } x=l\end{aligned}\right\}\ldots\ldots[8]$$

where β and γ are the equivalent radiation heat-transfer coefficients at the bottom and the top of the bed, respectively. The quantity $\rho U/k$ is included as a coefficient in the first of Equations [8] because it is necessary to provide sufficient heat at the bottom of the bed to raise the temperature of the incoming fresh fuel from that of the surroundings to that of the bed at $x = 0$.

The temperature of the air entering the fuel bed is, of course, that of the surroundings, so that the initial condition on T_a is

$$T_a = 0\ldots\ldots\ldots\ldots[9]$$

at $x = 0$. The concentration of oxygen in the entering air has its initial value P_1, which is maintained until combustion starts at $x = x_1$, while over the same range the concentrations of carbon dioxide and carbon monoxide remain zero, so that

$$\left.\begin{aligned}&p_1=P_1,\quad \text{when } x\leqslant x_1\\&p_2=p_3=0,\ \text{when } x\leqslant x_1\end{aligned}\right\}\ldots\ldots[10]$$

In the steady state the rate of fuel flow U is equal to the rate of combustion, so it may be calculated from the gas analysis at the top of the bed, giving

$$U = M\,G\,[p_2(l)+p_3(l)]\ldots\ldots\ldots\ldots[11]$$

where M is a stoichiometric factor. It may be noted that, in the steady state, overfeed combustion would be represented by changing the sign of U.

Solution of the Differential Equations

Equations [7] with the initial conditions of Equations [10] can be solved immediately, giving

$$p_1=\left\{\begin{aligned}&P_1,\ \text{when } x\leqslant x_1\\&P_1e^{-\frac{\mu_1}{G}(x-x_1)},\ \text{when } x_1\leqslant x\leqslant l\end{aligned}\right\}\ldots\ldots[12]$$

$$p_2=\left\{\begin{aligned}&0,\ \text{when } x\leqslant x_1\\&\frac{P_1}{1-\frac{\mu_2}{\mu_1}}\left[e^{-\frac{\mu_2}{G}(x-x_1)}-e^{-\frac{\mu_1}{G}(x-x_1)}\right]\ \text{when } x_1\leqslant x\leqslant l\end{aligned}\right\}\ [13]$$

$$p_3=\left\{\begin{aligned}&0,\ \text{when } x\leqslant x_1\\&2P_1\left[1-\frac{e^{-\frac{\mu_2}{G}(x-x_1)}-\frac{\mu_2}{\mu_1}e^{-\frac{\mu_1}{G}(x-x_1)}}{1-\frac{\mu_2}{\mu_1}}\right],\\&\qquad\text{when } x_1\leqslant x\leqslant l\end{aligned}\right\}\ldots[14]$$

Using these values of p, the combustion rate U may be calculated from Equation [11], giving

$$U = GP_1M\left[\left(1\quad e^{-\frac{\mu_1}{G}(l-x_1)}\right)+\left(1-\frac{e^{-\frac{\mu_2}{G}(l-x_1)}-\frac{\mu_2}{\mu_1}e^{-\frac{\mu_1}{G}(l-x_1)}}{1-\frac{\mu_2}{\mu_1}}\right)\right]\ldots[15]$$

Equations [12], [13], and [14] are essentially the same as those reported recently by Furnas (12) except that the K values used by him are replaced here by μ/G.

In order to determine T it is necessary to eliminate T_a between Equations [5] and [6], giving

$$\frac{d^3T}{dx^3}-2b\frac{d^2T}{dx^2}-(c^2-b^2)\frac{dT}{dx}$$
$$=\left\{\begin{aligned}&0,\ \text{when } 0\leqslant x\leqslant x_1\\&-\frac{\mu_1h_1}{k}\left(\frac{\alpha}{Gc_p}p_1+\frac{dp_1}{dx}\right)+\frac{\mu_2h_2}{k}\left(\frac{\alpha}{Gc_p}p_2+\frac{dp_2}{dx}\right),\\&\qquad\text{when } x_1\leqslant x\leqslant l\end{aligned}\right\}\ldots[16]$$

where

$$b=\frac{1}{2}\left(\frac{\rho U}{k}-\frac{\alpha}{Gc_p}\right)=\frac{1}{2}\sqrt{\frac{\alpha}{k}}\left(\frac{\rho U}{\sqrt{\alpha k}}-\frac{\sqrt{\alpha k}}{Gc_p}\right)\ldots[17]$$

and

$$c^2=\frac{\alpha}{k}\left(1+\frac{\rho U}{Gc_p}\right)+b^2=\frac{\alpha}{k}\left[1+\frac{1}{4}\left(\frac{\rho U}{\sqrt{\alpha k}}+\frac{\sqrt{\alpha k}}{Gc_p}\right)^2\right].[18]$$

while the boundary condition expressed by Equation [9] is replaced by

$$\frac{d^2T}{dx^2}-\frac{\rho U}{k}\frac{dT}{dx}-\frac{\alpha}{k}T=0\ldots\ldots\ldots[19]$$

at $x = 0$. A solution of the system defined by Equations [16], [19], and [8] could be obtained by the use of Green's function in the form of its bilinear expansion, but the resulting series converges very slowly because of the magnitude of c. Hence, elementary methods give a more satisfactory form of solution. The appropriate forms for the solution are

$$T = e^{bx}(A\cosh cx + B\sinh cx)+C\ldots\ldots[20a]$$

when $0\leqslant x\leqslant x_1$

$$T = e^{bx}(A\cosh cx+B\sinh cx)+e^{b(x-x_1)}(D\cosh c(x-x_1)$$
$$+E\sinh c(x-x_1))+F+\psi(x,x_1)\ldots[20b]$$

when $x_1\leqslant x\leqslant l$ and where ψ is the particular solution required for the right-hand side of Equations [16] when the values of p_1 and p_2 are substituted from Equations [12] and [13], and is given by

$$\psi = -\frac{P_1 h_1 \left(\frac{\alpha}{c_p} - \mu_1\right) e^{-\frac{\mu_1}{G}(x-x_1)}}{k\left[c^2 - \left(b + \frac{\mu_1}{G}\right)^2\right]} + \frac{P_1 h_2}{k\left(1 - \frac{\mu_2}{\mu_1}\right)} \left\{\frac{\left(\frac{\alpha}{c_p} - \mu_2\right) e^{-\frac{\mu_2}{G}(x-x_1)}}{c^2 - \left(b + \frac{\mu_2}{G}\right)^2} - \frac{\frac{\mu_2}{\mu_1}\left(\frac{\alpha}{c_p} - \mu_1\right) e^{-\frac{\mu_1}{G}(x-x_1)}}{c^2 - \left(b + \frac{\mu_1}{G}\right)^2}\right\} \quad \text{[20c]}$$

The six arbitrary constants A to F, inclusive, are determined by a system of six linear equations; three given by the boundary conditions of Equations [19] and [8]; two more by the obvious requirements that the temperature and its first derivative be continuous at $x = x_1$; and the last, by the equation, obtained by eliminating T, dT/dx, and T_a between the two expressions of Equation [5] evaluated at $x = x_1$

$$\left.\frac{d^2T}{dx^2}\right|^{x_1+0} - \left.\frac{d^2T}{dx^2}\right|^{x_1-0} = -\frac{1}{k}\left[\mu_1 h_1 p_1(x_1) - \mu_2 h_2 p_2(x_1)\right] \quad \text{[21]}$$

These equations are given in the Appendix.

The complete expressions for the temperature given in the Appendix are rather complicated, but they may be considerably simplified by the application of the approximation, correct to within 0.3 per cent when u is greater than 3, that

$$\cosh u = \sinh u = \frac{1}{2} e^u$$

Because of the great magnitude of c as defined by Equation [18] cl is greater than 3 for all practical fuel beds. With this approximation, T for the region where $x > x_1$ is given by

$$T = P_1 \left\{ h_1 \left[\frac{1 - e^{-(c-b)(x-x_1)}}{c_p + \frac{U}{G}\rho} - \frac{e^{-\frac{\mu_1}{G}(x-x_1)} - e^{-(c-b)(x-x_1)}}{\frac{c_p}{1 - \mu_1/\frac{\alpha}{c_v}} + \frac{U}{G}\rho + \frac{\mu_1 k}{G^2}} \right] \right.$$

$$- h_2 \left[\frac{1 - e^{-(c-b)(x-x_1)}}{c_p + \frac{U}{G}\rho} - \frac{1}{1 - \frac{\mu_2}{\mu_1}} \left(\frac{e^{-\frac{\mu_2}{G}(x-x_1)} - e^{-(c-b)(x-x_1)}}{\frac{c_p}{1 - \mu_2/\frac{\alpha}{c_p}} + \frac{U}{G}\rho + \frac{\mu_2 k}{G^2}} \right.\right.$$

$$\left.\left.\left. - \frac{\mu_2}{\mu_1} \frac{e^{-\frac{\mu_1}{G}(x-x_1)} - e^{-(c-b)(x-x_1)}}{\frac{c_p}{1 - \mu_1/\frac{\alpha}{c_p}} + \frac{U}{G}\rho + \frac{\mu_1 k}{G^2}} \right) \right] \right\} \left[1 - \frac{\frac{\gamma}{k} e^{-(c+b)(l-x)}}{c + b + \frac{\gamma}{k}} \right]$$

$$+ P_1 \frac{\mu_1 \left(c + b + \frac{\alpha}{Gc_p}\right) e^{-(c-b)(x-x_1)}}{2kc(c+b)\left(c + b + \frac{\mu_1}{G}\right)} \left(h_1 - \frac{\frac{\mu_2}{G} h_2}{c + b + \frac{\mu_2}{G}} \right) \quad \text{[22]}$$

Below the plane of ignition, where $x < x_1$

$$T = T_1 e^{-(c+b)(x_1-x)} \quad \text{[23]}$$

where cx_1 is greater than 3. In this expression, T_1 is the temperature at the plane of ignition, and is given by

$$T_1 = P_1 \left[\frac{\mu_1 \left(c + b + \frac{\alpha}{Gc_p}\right)\left(h_1 - \frac{\frac{\mu_2}{G} h_2}{c + b + \frac{\mu_2}{G}}\right)}{2kc(c+b)\left(c + b + \frac{\mu_1}{G}\right)} \right.$$

$$- \frac{h_1 \frac{\gamma}{k} e^{-(c+b)(l-x_1)}}{c + b + \frac{\gamma}{k}} \cdot \left(\frac{1}{c_p + \frac{U}{G}\rho} \right.$$

$$\left.\left. - \frac{\left(1 - \frac{\mu_1}{G} \Big/ \frac{\gamma}{k}\right) e^{-\frac{\mu_1}{G}(l-x_1)}}{\frac{c_p}{1 - \mu_1/\frac{\alpha}{c_p}} + \frac{U}{G}\rho + \frac{\mu_1 k}{G^2}} \right) \right] \quad \text{[24]}$$

Restricted and Unrestricted Ignition

The temperature at the plane of ignition T_1, could now be calculated from Equation [24] for various assumed values of $(l - x_1)$ and G, and the assumption of an ignition temperature for the fuel would fix the relation between the first two variables. It is found, however, that this holds only above a certain minimum value of G; below this value, T_1 will be greater than the ignition temperature, no matter how great $(l - x_1)$ be taken. This result evidently is equivalent to the effect found experimentally by Nicholls (6) that below some value of air-flow rate, the rate of advance of the ignition zone is greater than the rate of combustion.

In this region the definitions of restricted and unrestricted ignition, given by Nicholls, will be adopted. In combustion with unrestricted ignition, the fuel is fed at the rate of advance of the plane of ignition, so that the temperature elevation of the fuel at its inlet is zero. This condition is not practically desirable as it leads to a fuel bed of continually increasing thickness. It can, however, be calculated from the results of the previous section. Inspection of Equation [22] shows that the effect of radiation from the top surface of the fuel bed, given by the factor

$$\left[1 - \frac{\frac{\gamma}{k} e^{-(c+b)(l-x)}}{c + b + \frac{\gamma}{k}} \right]$$

extends only a short distance into the fuel bed, and is entirely negligible at $x = x_1$ for beds of practical thickness. Hence, the condition that the fuel bed must remain of constant thickness, given by Equation [15], may be abrogated, and U may be determined by the condition that

$$T_1 = T_i \quad \text{[25]}$$

where T_i is the ignition temperature of the fuel. For this case, only the first term of Equation [24] defining T_1, is significant, and Equation [25] may be put in the form

$$\frac{c_p T_i}{P_1 h_1} = \frac{\mu_1}{2\frac{\alpha}{c_p}} \frac{\left[\sqrt{1+\theta^2} + \theta\right]}{\sqrt{1+\theta^2}\left[\sqrt{1+\theta^2} + \theta - \frac{\sqrt{\alpha k}}{Gc_p}\right]} \times \frac{1}{\left[\sqrt{1+\theta^2} + \theta - \frac{\sqrt{\alpha k}}{Gc_p}\left(1 - \mu_1/\frac{\alpha}{c_p}\right)\right]} \quad \text{[26]}$$

where $\theta = \frac{1}{2}\left[\frac{\rho U}{\sqrt{\alpha k}} + \frac{\sqrt{\alpha k}}{G c_p}\right]$, so that all the terms are dimensionless.

In combustion with restricted ignition, the fuel-bed thickness is maintained constant, and the temperature of the bed at its base is above the ignition temperature, so that $x_1 = 0$ and combustion occurs throughout the height of the bed. For this condition a slightly different form of solution for the temperature T is required, as, since $x_1 = 0$, the continuity conditions of Equation [21] and the preceding paragraph need not be satisfied. The appropriate form is

$$T = e^{bx}\left[A' \cosh cx + B' \sinh cx\right] + C' + \psi(X) \ldots\ldots [27]$$

where ψ has the same value as in Equation [20c] except that x_1 vanishes. The constants A', B', and C' are determined by the three boundary conditions given in Equations [8] and [19], and the solution, abridged in the same way as that of Equation [22] is

$$T = P_1 \left\{ h_1 \left[\frac{\left(1 - \mu_1 / \frac{\alpha}{c_p}\right)\left(1 - e^{-(c-b)x}\right)}{c_p + \frac{U}{G}\rho} - \frac{e^{-\frac{\mu_1}{G}x} - e^{-(c-b)x}}{\frac{c_p}{1 - \mu_1/\frac{\alpha}{c_p}} + \frac{U}{G}\rho + \frac{\mu_1 k}{G^2}} \right] \right.$$

$$- h_2 \left[\frac{1 - e^{-(c-b)x}}{c_p + \frac{U}{G}\rho} - \frac{1}{1 - \frac{\mu_2}{\mu_1}} \left(\frac{e^{-\frac{\mu_2}{G}x} - e^{-(c-b)x}}{\frac{c_p}{1 - \mu_2/\frac{\alpha}{c_p}} + \frac{U}{G}\rho + \frac{\mu_2 k}{G^2}} \right. \right.$$

$$\left. \left. \left. - \frac{\frac{\mu_2}{\mu_1}\left(e^{-\frac{\mu_1}{G}x} - e^{-(c-b)x}\right)}{\frac{c_p}{1 - \mu_1/\frac{\alpha}{c_p}} + \frac{U}{G}\rho + \frac{\mu_1 k}{G^2}} \right) \right] \right\} \left[1 - \frac{\frac{\gamma}{k} e^{-(c-b)(l-x)}}{c + b + \frac{\gamma}{k}} \right]$$

$$+ P_1 \frac{\mu_1 \left[e^{-(c-b)x} - \frac{\beta}{\beta + \rho U + G c_p} \left(1 - \frac{\frac{\gamma}{k} e^{-(c+b)(l-x)}}{c + b + \frac{\gamma}{k}} \right) \right]}{k(c+b)\left(c + b + \frac{\mu_1}{G}\right)\left(c - b + \frac{\beta + \rho U}{k} \frac{\rho U + G c_p}{\beta + \rho U + G c_p}\right)}$$

$$\left[\left(\frac{\alpha}{G c_p} - \frac{\mu_1}{G} \right) h_1 - \frac{\frac{\mu_2}{G}\left(c + b + \frac{\alpha}{G c_p}\right) h_2}{c + b + \frac{\mu_2}{G}} \right] \ldots . [28]$$

Comparison of Calculated and Experimental Results

In order to calculate results from the equations presented in this paper, it is necessary to make estimates of the values of the coefficients appearing in them. These coefficients have been subjected to sporadic and partial investigation only, and in many cases even their order of magnitude is not known. What information is available concerning them is dealt with by the author in another paper (13). The values of the coefficients used are given in Table 1. They were obtained by choosing those values from the literature which gave reasonably good agreement between the temperatures observed by Nicholls (14) and those calculated according to Equation [22].

TABLE 1 VALUES OF COEFFICIENTS USED IN THE VARIOUS EQUATIONS

Fuel size	$^1/_2 \times 1$ in.	$1 \times 1^1/_2$ in.	$2 \times 2^1/_2$ in.
α, Btu per cu ft per hr per deg F.	6350	6000	5350
k, Btu per ft per hr per deg F.	1.525	2.24	3.65
W,[a] lb per cu ft per hr	26.1	15.2	8.16
μ_2/μ_1	0.267, $x < 0.5$ ft;	$\mu_2/G = 0.03$, $x > 0.5$ ft	
β, Btu per sq ft per hr per deg F.		5.	
γ, Btu per sq ft per hr per deg F.		12.50	
ρ, Btu per lb per deg F.		0.34	
c_p, Btu per lb per deg F.		0.28	

[a] W is the coefficient of $G/100$ in the expression $\mu_1/G = W\,[(G/100)^{-0.5}]$

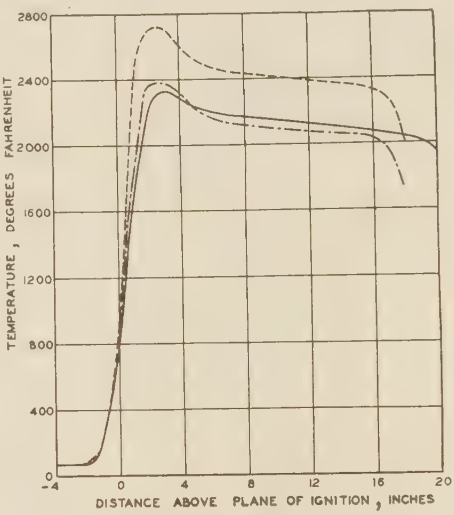


FIG. 2 TEMPERATURES IN UNDERFEED FUEL BED

(Solid curve plotted from experimental values (14). Dashed curve plotted from values calculated for unrestricted ignition. Dot-and-dash curve plotted from values calculated for restricted ignition. Air-flow rate = 160 lb per sq ft per hr, combustion rate = 25 lb per sq ft per hr, and rate of advance of ignition zone = 36.1 lb per sq ft per hr.)

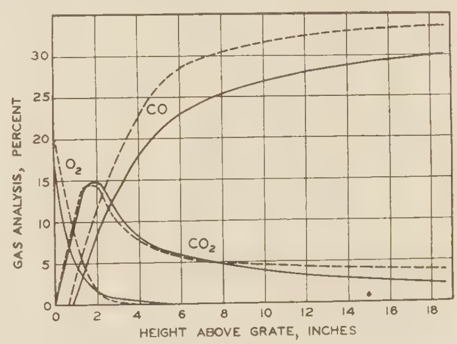


FIG. 3 GAS ANALYSIS IN A FUEL BED

(Solid curve plotted from experimental values (6, 7). Dashed curve plotted from calculated values.)

In Fig. 2, the full line shows the temperatures measured in an experimental underfeed fuel bed. The dashed line shows the temperatures calculated for the same conditions for unrestricted ignition from Equations [22] and [23] while the dot-and-dash line shows the temperatures calculated for restricted ignition from Equation [28]. In comparing the experimental and calculated curves for unrestricted ignition, the following points of difference appear:

(a) The calculated curve is from 200 F to 300 F higher than the experimental curve throughout the combustion zone. This may be due to heat loss from the sides of the experimental furnace, which, of course, could not be accounted for in the calculation considering only one dimension. It is difficult to account for this discrepancy by incorrect values of the coefficients, because the temperature in this region depends almost entirely on μ_1/G

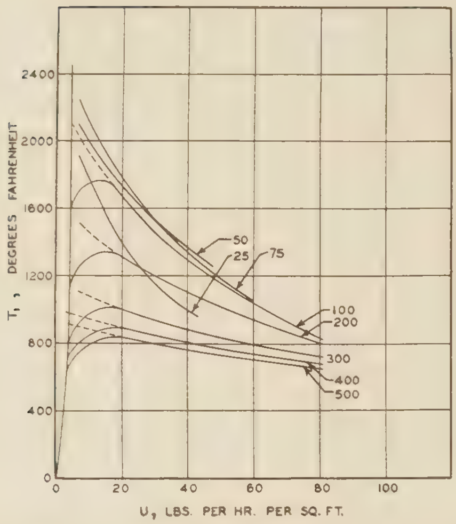


Fig. 4 Relation Between Temperature at the Plane of Ignition, and Rate of Ignition for Different Air-Flow Rates
(Numbers on curves represent air-flow rates in pounds per square foot per hour.)

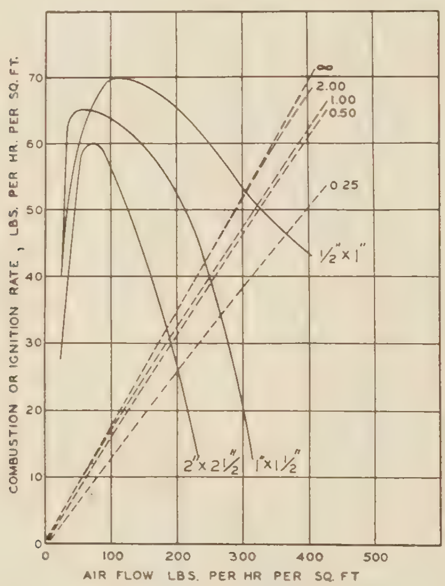


Fig. 5 Calculated Relation Between Combustion or Ignition Rates and Air-Flow Rates
(The solid curves give ignition rates, i.e., 1 in. × 1½ in. represents the rate of advance of the ignition zone for a fuel sized through 1½ in. and 1 in. screens. The dashed curves represent combustion rates; the numbers on each curve give depth of fuel bed in feet.)

and μ_2/G, and these are fixed quite exactly by the gas analysis given in Fig. 3.

(b) The slope of the calculated curve below the plane of ignition is steeper than that of the experimental curve. This is due to incorrect choice of the coefficients α and k. Evidently they should be still larger than those actually used, although those used are actually at the upper limits of what can be justified by existing measurements.

(c) The drop in temperature at the top of the bed ($x = 18$ in.) is much greater in the calculated than in the experimental curves. This is partially due to the same error as in (2), and also to the fact that insufficient allowance appears to have been made in the calculation for the decrease in heat loss by radiation from the top of the fuel bed due to the flame of combustible gases leaving the bed.

Comparison of the curves for unrestricted and restricted ignition shows that the temperature in the bed with restricted ignition is more than 300 F less than that with unrestricted ignition, even though the former bed is igniting fuel at only six tenths the rate at which the latter is. This difference represents the heat radiated downward to the grate by the bed with restricted ignition, and is the source of the destructive heating of the stoker parts so well known to stoker operators.

Fig. 3 shows the gas analysis at various points in the fuel bed. The analysis determined experimentally is given by the solid line, and that for both calculated cases is given by the dashed line.

It is to be noted that no correction has been made in the calculated analyses for the expansion of the gas due to the reaction forming carbon monoxide. This leads to an error, negligible at low CO concentrations, but appreciable at higher ones.

Fig. 4 shows the relation between T_i, U_i, and G determined by Equation [26]. By the use of a set of such curves as this, cal-

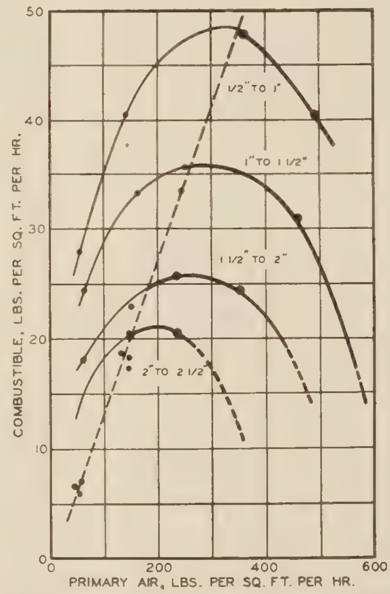


Fig. 6 Experimental Combustion and Ignition Rates in Relation to Air-Flow Rate as Given by Nicholls and Eilers (7)

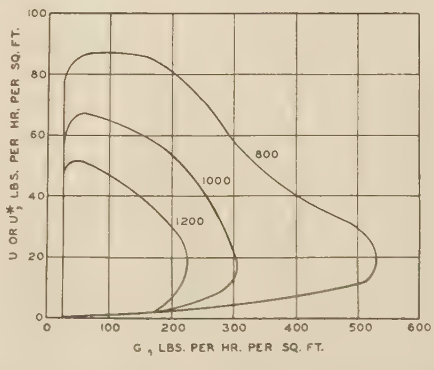


Fig. 7 Calculated Rates of Ignition in Relation to Air-Flow Rate for Various Ignition Temperatures
(Numbers on curves represent ignition temperatures, deg F.)

culated for various fuel sizes, the solid lines of Fig. 5 may be obtained by plotting U_i against G for any fixed value of T_i. Fig. 5 is to be compared with Fig. 6, the relation found experimentally between U_i and G (6, 7). The dashed lines of Fig. 5 represent the combustion rate, calculated from Equation [15] for various thicknesses of the combustion zone. They are to be compared with the sloping line of Fig. 6, in which, however, the combustion-zone thickness was not controlled, but was allowed to increase continuously. It will be observed that in the region covered by the curves of Figs. 5 and 6, there are no discrepancies that better knowledge of the coefficients may not be expected to remove.

Fig. 7 shows the relation between U_i and G for several different values of the ignition temperature, defining completely the area in which self-ignition by underfeed action is possible. This figure shows how important this characteristic is in determining the combustion properties of different fuels. Other significant properties of fuel beds that may be calculated by means of the expressions derived in this paper are discussed by the author in another paper (13).

Acknowledgments

The author wishes to acknowledge his indebtedness to Dr. H. H. Lowry, director of the Coal Research Laboratory, without whose encouragement this work would not have been completed; to Dr. Leo Kasehagen of this laboratory for his assistance in checking the mathematics; and to other engineers and scientists, including especially L. A. Shipman, of the Southern Coal and Coke Company, and P. Nicholls of the U. S. Bureau of Mines, whose discussions of this material have helped to clarify the significance of various factors.

Conclusions

The characteristics of pure underfeed combustion, calculated theoretically on the hypothesis that the fuel bed behaves like a heat-conducting solid in the interstices of which convection and combustion occur, have been shown to duplicate with considerable fidelity the experimental determinations of those characteristics.

The analysis is also immediately applicable to overfeed fuel beds by merely changing the sign of the combustion rate U, and making the necessary modifications of the coefficients occurring in the boundary conditions.

The results indicate the significance of various chemical and physical factors in determining the combustion characteristics of fuels, and show the need for research investigations of the heat-transfer coefficients in, and the thermal conductivity of, beds of broken solids.

The method of analysis may be applied only in a general way to real fuel beds, since these are not usually pure underfeed beds, but operate largely on a side-feed principle in which air and fuel move in directions roughly at right angles. The analytical investigation of this case is more complicated, but probably not beyond the possibility of solution.

Appendix

Unrestricted Ignition

The Constants of Equations [20a], [20b], and [20c]

The six constants A, B, C, D, E, and F are determined by the six equations obtained by substituting the expressions given in Equations [20a], [20b], and [20c] into the boundary conditions of Equations [8] and [19], and the continuity conditions given by Equation [21] and the paragraph preceding it.

These equations are

$$-\left(\frac{\beta+\rho U}{k}-b\right)A+cB-\frac{\beta+\rho U}{k}C=0 \ldots\ldots [1A]$$

$$e^{bl}\left[\left(b+\frac{\gamma}{k}\right)\cosh cl+c\sinh cl\right]A+e^{bl}\left[\left(b+\frac{\gamma}{k}\right)\sinh cl+c\cosh cl\right]B+e^{b(l-x_1)}\left[\left(b+\frac{\gamma}{k}\right)\cosh c(l-x_1)+c\sinh c(l-x_1)\right]D+e^{b(l-x_1)}\left[\left(b+\frac{\gamma}{k}\right)\sinh c(l-x_1)+c\cosh c(l-x_1)\right]E+\frac{\gamma}{k}F$$

$$=\frac{\left(\frac{\gamma}{k}-\frac{\mu_1}{G}\right)\left(\frac{\alpha}{Gc_p}-\frac{\mu_1}{G}\right)e^{-\frac{\mu_1}{G}(l-x_1)}}{\frac{u_1}{G}\left[c_2-\left(b+\frac{\mu_1}{G}\right)^2\right]}Q-\frac{\left(\frac{\gamma}{k}-\frac{\mu_2}{G}\right)\left(\frac{\alpha}{Gc_p}-\frac{\mu_2}{G}\right)e^{-\frac{\mu_2}{G}(l-x_1)}}{\frac{\mu_2}{G}\left[c^2-\left(b+\frac{\mu_2}{G}\right)^2\right]}R \ldots\ldots [2A]$$

$$\left(c^2+b^2-\frac{\rho U}{k}b-\frac{\alpha}{k}\right)A-c\left(\frac{\rho U}{k}-2b\right)B-\frac{\alpha}{k}C=0 \ldots\ldots [3A]$$

$$-C+D+F=\frac{\left(\frac{\alpha}{Gc_p}-\frac{\mu_1}{G}\right)Q}{\frac{\mu_1}{G}\left[c^2-\left(b+\frac{\mu_1}{G}\right)^2\right]}-\frac{\left(\frac{\alpha}{Gc_p}-\frac{\mu_2}{G}\right)R}{\frac{\mu_2}{G}\left[c^2-\left(b+\frac{\mu_2}{G}\right)^2\right]} \ldots\ldots [4A]$$

$$bD+cE=-\frac{\left(\frac{\alpha}{Gc_p}-\frac{\mu_1}{G}\right)Q}{c^2-\left(b+\frac{\mu_1}{G}\right)^2}+\frac{\left(\frac{\alpha}{Gc_p}-\frac{\mu_2}{G}\right)R}{c^2-\left(b+\frac{\mu_2}{G}\right)^2} \ldots [5A]$$

$$(c^2+b^2)D+2bcE=\left[\frac{\frac{\mu_1}{G}\left(\frac{\alpha}{Gc_p}-\frac{\mu_1}{G}\right)}{c^2-\left(b+\frac{\mu_1}{G}\right)^2}-1\right]Q-\left[\frac{\frac{\mu_2}{G}\left(\frac{\alpha}{Gc_p}-\frac{\mu_2}{G}\right)}{c^2-\left(b+\frac{\mu_2}{G}\right)^2}-1\right]R \ldots\ldots [6A]$$

where

$$Q=\frac{\mu_1 P_1}{k}\left(h_1+\frac{\mu_2 h_2}{(\mu_1-u_2)}\right)$$

and

$$R=\frac{\mu_1\mu_2 P_1 h_2}{(\mu_1-\mu_2)\,k}$$

The solution of this system gives the values of the constants in terms of the quantities b, c, μ_1/G, μ_2/G, β, and γ, but the result may be simplified by making use of the five following conventions

$$\tanh \sigma = \frac{\dfrac{\beta + \rho U}{k}\,\dfrac{\rho U + Gc_p}{\beta + \rho U + Gc_p} - b}{c} \qquad \text{[7A]}$$

$$\tanh s = \frac{b}{c} \qquad \text{[9A]}$$

$$\tanh \tau = \frac{\dfrac{\gamma}{k} + b}{c} \qquad \text{[8A]}$$

$$\tanh t_1 = \frac{b + \dfrac{\mu_1}{G}}{c} \qquad \text{[10A]}$$

$$\tanh t_2 = \frac{b + \dfrac{\mu_2}{G}}{c} \qquad \text{[11A]}$$

when the solution to Equation [16] may be written

(*a*) for the region $0 \leqslant x \leqslant x_1$

$$T = P_1 \frac{e^{bx}\cosh(cx+\sigma) - \dfrac{\beta\cosh\sigma}{\beta+\rho U+Gc_p}}{e^{bl}\sinh(cl+\sigma+\tau) - \dfrac{\beta\gamma\cosh\sigma\sinh\tau}{(\beta+\rho U+Gc_p)(\gamma+kb)}} \Bigg[h_1 \Bigg\{ \frac{1}{c_p + \dfrac{U}{G}\rho} \Bigg(\frac{e^{b(l-x_1)}\sinh[c(l-x_1)+\tau-s]}{\cosh s} - \frac{\dfrac{\gamma}{k}\sinh\tau}{b+\dfrac{\gamma}{k}} \Bigg)$$

$$- \frac{1}{\dfrac{c_p}{1-\mu_1/\dfrac{\alpha}{c_p}} + \dfrac{U}{G}\rho + \dfrac{\mu_1 k}{G^2}} \Bigg(\frac{e^{b(l-x_1)}\sinh[c(l-x_1)+\tau-t_1]}{\cosh t_1} - \frac{\left[\dfrac{\gamma}{k} - \dfrac{\mu_1}{G}\right]\sinh\tau}{b+\dfrac{\gamma}{k}} e^{-\frac{\mu_1}{G}(l-x_1)} \Bigg) \Bigg\}$$

$$- h_2 \Bigg\{ \frac{1}{c_p + \dfrac{U}{G}\rho} \Bigg(\frac{e^{b(l-x_1)}\sinh[c(l-x_1)+\tau-s]}{\cosh s} - \frac{\dfrac{\gamma}{k}\sinh\tau}{b+\dfrac{\gamma}{k}} \Bigg) - \frac{1}{1-\dfrac{\mu_2}{\mu_1}} \Bigg(\frac{1}{\dfrac{c_p}{1-\mu_2/\dfrac{\alpha}{c_p}} + \dfrac{U}{G}\rho + \dfrac{\mu_2 k}{G^2}}$$

$$\times \Bigg[\frac{e^{b(l-x_1)}\sinh[c(l-x_1)+\tau-t_2]}{\cosh t_2} - \frac{\left(\dfrac{\gamma}{k} - \dfrac{\mu_2}{G}\right)}{b+\dfrac{\gamma}{k}} e^{-\frac{\mu_2}{G}(l-x_1)} \sinh\tau \Bigg] - \frac{\dfrac{\mu_2}{\mu_1}}{\dfrac{c_p}{1-\mu_1/\dfrac{\alpha}{c_p}} + \dfrac{U}{G}\rho + \dfrac{\mu_1 k}{G^2}}$$

$$\times \Bigg[\frac{e^{b(l-x_1)}\sinh[c(l-x_1)+\tau-t_1]}{\cosh t_1} - \frac{\left(\dfrac{\gamma}{k} - \dfrac{\mu_1}{G}\right)}{b+\dfrac{\gamma}{k}} e^{-\frac{u_1}{G}(l-x_1)} \Bigg] \Bigg) \Bigg\} \Bigg] \qquad \text{[12A]}$$

(*b*) for the region $x_1 \leqslant x \leqslant l$

$$T = P_1 \Bigg\{ \frac{h_1 - h_2}{c_p + \dfrac{U}{G}\rho} \Bigg[1 - \frac{e^{b(l+x-x_1)}\sinh(cx_1+\sigma+s)\cosh[c(l-x)+\tau]}{\cosh s\left[e^{bl}\sinh(cl+\sigma+\tau) - \dfrac{\beta\gamma\cosh\sigma\sinh\tau}{(\beta+\rho U+Gc_p)(\gamma+kb)}\right]}$$

$$- \frac{\dfrac{\beta\cosh\sigma}{\beta+\rho U+Gc_p}\left[e^{b(l-x_1)}\sinh\{c(l-x_1)+\tau-s\} - \dfrac{\gamma\sinh\tau}{\gamma+kb} e^{b(x-x_1)}\cosh\{c(x-x_1)-s\}\right]}{\cosh s\left[e^{bl}\sinh(cl+\sigma+\tau) - \dfrac{\beta\gamma\cosh\sigma\sinh\tau}{(\beta+\rho U+Gc_p)(\gamma+kb)}\right]}$$

$$- \frac{\dfrac{\gamma\sinh\tau}{\gamma+kb}\left[e^{bx}\cosh(cx+\sigma) - \dfrac{\beta\cosh\sigma}{\beta+\rho U+Gc_p}\right]}{e^{bl}\sinh(cl+\sigma+\tau) - \dfrac{\beta\gamma\cosh\sigma\sinh\tau}{(\beta+\rho U+Gc_p)(\gamma+kb)}} \Bigg] - \frac{h_1 + \dfrac{\mu_2 h_2}{(\mu_1-\mu_2)}}{\dfrac{c_p}{1-\mu_1/\dfrac{\alpha}{c_p}} + \dfrac{U}{G}\rho + \dfrac{\mu_1 k}{G^2}}$$

$$\left[e^{-\frac{u_1}{G}(l-x)} - \frac{e^{b(l+x-x_1)}\sinh(cx_1+\sigma+t_1)\cosh[c(l-x)+\tau]}{\cosh t_1\left[e^{bl}\sinh(cl+\sigma+\tau) - \frac{\beta\gamma\cosh\sigma\sinh\tau}{(\beta+\rho U+Gc_p)(\gamma+kb)}\right]}\right.$$

$$-\frac{\frac{\beta\cosh\sigma}{\beta+\rho U+Gc_p}\left[e^{b(l-x_1)}\sinh\{c(l-x_1)+\tau-t_1\} - \frac{\gamma\sin\tau}{\gamma+kb}e^{b(x-x_1)}\cosh\{c(x-x_1)-t_1\}\right]}{\cosh t_1\left[e^{bl}\sinh(cl+\sigma+\tau) - \frac{\beta\gamma\cosh\sigma\sinh\tau}{(\beta+\rho U+Gc_p)(\gamma+kb)}\right]}$$

$$\left.-\frac{\frac{\left(\frac{\gamma}{k}-\frac{\mu_1}{G}\right)\sinh\tau}{\frac{\gamma}{k}+b}\, e^{-\frac{u_1}{G}(l-x_1)}\left[e^{bx}\cosh(cx+\sigma)-\frac{\beta\cosh\sigma}{\beta+\rho U+Gc_p}\right]}{e^{bl}\sinh(cl+\sigma+\tau)-\frac{\beta\gamma\cosh\sigma\sinh\tau}{(\beta+\rho U+Gc_p)(\gamma+kb)}}\right]$$

$$+\frac{\frac{\mu_1 h_2}{\mu_1-\mu_2}}{\frac{c_p}{1-\mu_2/\frac{\alpha}{c_p}}+\frac{U}{G}\rho+\frac{\mu_2 k}{G^2}}\left[e^{-\frac{u_2}{G}(l-x)} - \frac{e^{b(l+x-x_1)}\sinh(cx_1+\sigma+t_2)\cosh[c(l-x)+\tau]}{\cosh t_2\left[e^{bl}\sinh(cl+\sigma+\tau) - \frac{\beta\gamma\cosh\sigma\sinh\tau}{(\beta+\rho U+Gc_p)(\gamma+kb)}\right]}\right.$$

$$-\frac{\frac{\beta\cosh\sigma}{\beta+\rho U+Gc_p}\left[e^{b(l-x_1)}\sinh\{c(l-x_1)+\tau-t_2\} - \frac{\gamma\sinh\tau}{\gamma+kb}e^{b(x-x_1)}\cosh\{c(x-x_1)-t_2\}\right]}{\cosh t_2\left[e^{bl}\sinh(cl+\sigma+\tau) - \frac{\beta\gamma\cosh\sigma\sinh\tau}{(\beta+\rho U+Gc_p)(\gamma+kb)}\right]}$$

$$\left.\left.-\frac{\frac{\left(\frac{\gamma}{k}-\frac{\mu_2}{G}\right)}{\frac{\gamma}{k}+b}\sinh\tau\, e^{-\frac{\mu_2}{G}(l-x_1)}\left[e^{bx}\cosh(cx+\sigma)-\frac{\beta\cosh\sigma}{\beta+\rho U+Gc_p}\right]}{e^{bl}\sinh(cl+\sigma+\tau)-\frac{\beta\gamma\cosh\sigma\sinh\tau}{(\beta+\rho U+Gc_p)(\gamma+kb)}}\right]\right\} \quad \ldots\ldots\ldots\ldots [13A]$$

In simplifying these expressions by the use of the device stated in the section "Solution of Differential Equations" of the paper, the second term in the denominator of each of the fractions within the brackets in Equation [13A] may be neglected by comparison with the first term.

RESTRICTED IGNITION

The Constants of Equation [27]

The three constants, A', B', and C' are determined by the three equations

$$-\left(\frac{\beta+\rho U}{k}-b\right)A' + cB' - \frac{\beta+\rho U}{k}C' = -\frac{\left(\frac{\mu_1}{G}+\frac{\beta+\rho U}{k}\right)Q'}{\frac{\mu_1}{G}\left[c^2-\left(b+\frac{\mu_1}{G}\right)^2\right]} + \frac{\left(\frac{\mu_2}{G}+\frac{\beta+\rho U}{k}\right)R'}{\frac{\mu_2}{G}\left[c^2-\left(b+\frac{\mu_2}{G}\right)^2\right]} \quad \ldots [14A]$$

$$e^{bl}\left[\left(b+\frac{\gamma}{k}\right)\cosh cl + c\sinh cl\right]A' + e^{bl}\left[\left(b+\frac{\gamma}{k}\right)\sinh cl + c\cosh cl\right]B' + \frac{\gamma}{k}C' = \frac{\left(\frac{\gamma}{k}-\frac{\mu_1}{G}\right)e^{-\frac{\mu_1}{G}l}}{\frac{\mu_1}{G}\left[c^2-\left(b+\frac{\mu_1}{G}\right)^2\right]}Q'$$

$$-\frac{\left(\frac{\gamma}{k}-\frac{\mu_2}{G}\right)e^{-\frac{\mu_2}{G}l}}{\frac{\mu_2}{G}\left[c^2-\left(b+\frac{\mu_2}{G}\right)^2\right]}R' \quad \ldots [15A]$$

$$\left(c^2+b^2-\frac{\rho U}{k}b-\frac{\alpha}{k}\right)A'-c\left(\frac{\rho U}{k}-2b\right)B'-\frac{\alpha}{k}C' = \frac{\left[\left(\frac{\mu_1}{G}\right)^2+\frac{\mu_1}{G}\frac{\rho U}{k}-\frac{\alpha}{k}\right]Q'}{\frac{\mu_1}{G}\left[c^2-\left(b+\frac{\mu_1}{G}\right)^2\right]}-\frac{\left[\left(\frac{\mu_2}{G}\right)^2+\frac{\mu_2}{G}\frac{\rho U}{k}-\frac{\alpha}{k}\right]R'}{\frac{\mu_2}{G}\left[c^2-\left(b+\frac{\mu_2}{G}\right)^2\right]} \quad [16A]$$

where $Q' = \frac{\mu_1 P_1}{k}\left(\frac{\alpha}{Gc_p}-\frac{\mu_1}{G}\right)\left(h_1+\frac{\mu_2 h_2}{\mu_1-\mu_2}\right)$ and $R' = \frac{\mu_1\mu_2 P_1}{(\mu_1-\mu_2)\,k}\left(\frac{\alpha}{Gc_p}-\frac{\mu_2}{G}\right)$

When this system is solved, it is found that the expression obtained for the temperature is identical with that given in Equation [13A], except that x_1 vanishes everywhere, and the coefficient of the first term, instead of being $(h_1 - h_2)/(c_p + U/G\rho)$ as it is in Equation [13A] is now

$$\frac{\left(1-\mu_1\Big/\frac{\alpha}{c_p}\right)h_1-h_2}{c_p+\frac{U}{G}\rho} \quad [17A]$$

BIBLIOGRAPHY

1 "Combustion in the Fuel Bed of Hand-Fired Furnaces," by H. Kreisinger, F. K. Ovitz, and G. E. Augustine; U. S. Bureau of Mines Technical Paper No. 137, 1916.

2 "Combustion Experiments With North Dakota Lignite," by H. Kreisinger, F. K. Ovitz, and W. C. Harpster, U. S. Bureau of Mines Technical Paper No. 207, 1919.

3 "Combustion of Blast-Furnace Cokes in Fuel Beds," by R. A. Sherman and J. Blizard, Transactions of the American Institute of Mining and Metallurgical Engineers, vol. 69, 1923, pp. 526–542.

4 "Coke for Blast Furnaces," by R. A. Mott and R. V. Wheeler, Colliery Guardian Company, Ltd., London, 1930, Table 43, p. 130.

5 "The Use of Coke for Domestic Purposes," by R. A. Mott, *Fuels*, vol. 15, March, 1936, pp. 77–81.

6 "Underfeed Combustion, Effect of Preheat, and Distribution of Ash in Fuel Beds," by P. Nicholls, U. S. Bureau of Mines Bulletin No. 378, 1934.

7 "The Principles of Underfeed Combustion and the Effect of Preheated Air on Overfeed and Underfeed Fuel Beds," by P. Nicholls and M. G. Eilers, Trans. A.S.M.E., vol. 56, 1934, paper FSP-56-5, pp. 321–336.

8 "The Physics of Coal Carbonization," by S. P. Burke, T. E. W. Schumann, and V. F. Parry, American Gas Association Proceedings, 1930, pp. 820–855.

9 "Beiträge zur Kenntnis der thermischen Grundlagen der Verschwelung und Verkokung von Braunkohlen," by E. Terres, et al., *Beiheft Zeitschrift des Vereins deutscher Chemiker*, no. 10, 1935.

10 "Beiträge zur Kenntnis der thermischen Grundlagen der Verschwelung und Verkokung von Braunkohlen," by E. Terres, et al., *Angewandte Chemie*, vol. 48, no. 1, 1935, pp. 17–21.

11 "The Basic Laws and Data of Heat Transmission," by W. J. King, *Mechanical Engineering*, vol. 54, 1932, Fig. 4, p. 496.

12 "Solid Carbon Reactivity," by C. C. Furnas, *Industrial and Engineering Chemistry*, vol. 28, 1936, pp. 498–502.

13 "Some Factors Affecting Combustion in Fuel Beds," by M. A. Mayers, American Institute of Mining and Metallurgical Engineers, Tech. Pub. No. 771, Class F, Coal Division, No. 83, 1937.

14 "Underfeed Combustion, Effect of Preheat, and Distribution of Ash in Fuel Bed," by P. Nicholls, U. S. Bureau of Mines Bulletin No. 378, 1934, Fig. 21, p. 50.

The Separation and Emission of Cinders and Fly Ash

By ARTHUR C. STERN,[1] NEW YORK, N. Y.

The author discusses the size-frequency analysis of cinders and fly ash, and the variation of the efficiency of dust separation with varying dust-particle size. He shows how these two factors may be combined to determine the overall efficiency of separation. He outlines a rational method for the calculation of dust separation and emission in complex fuel-burning units, in which the dust originates in the furnace, and must pass, prior to its emission into the atmosphere, through numerous heat-absorbing units, including some in which a measure of dust removal may occur. He points out what experimental data must be made available to designers before they may fully utilize any method of predetermining the operating characteristics of equipment with respect to cinder and fly-ash emission. He attempts a theoretical analysis of the efficiency of dust separation in settling chambers, centrifugal concentrators, and cyclone separators.

THE emission of cinder and fly-ash particles from the stacks of fuel-burning plants, particularly steam-generating plants, presents a real problem both from the points of view of air pollution and power-plant operation. Therefore, it is desirable that engineers be able to predetermine the quantity and character of this emission as part of the regular procedure in designing any installation of fuel-burning equipment. A method for making the necessary calculation for this purpose is outlined in this paper. This method of analysis also allows calculation of the quantity and character of the dust separated out of the flue-gas stream at various points in its path from furnace to stack.

Nomenclature

- μ = diameter of dust particle, microns ($1\ \mu = 10^{-4}$ cm)
- A = dust loading at any instant of time, weight of dust per unit volume of flue gas
- k = definite size interval, for instance, from 50 μ to 100 μ, or from 100 μ to 200 μ
- A_k = dust loading within size interval, k
- α = dust in suspension in the flue gas entering the unit
- β = dust in suspension in the flue gas leaving the unit
- γ = dust separated out of the flue gas in the unit
- $A_\alpha = A_\beta + A_\gamma$
- $A_{k\alpha} = A_{k\beta} + A_{k\gamma}$
- ϕ = overall efficiency of separation at any instant of time $= \dfrac{100\ A_\gamma}{A_\alpha} = \dfrac{100\ A_\gamma}{A_\beta + A_\gamma} = \dfrac{100\ (A_\alpha - A_\beta)}{A_\alpha}$
- λ = size efficiency, the efficiency of separation of a definite size interval of the dust at any instant of time
- λ_k = efficiency of separation of size interval $k = \dfrac{100\ A_{k\gamma}}{A_{k\alpha}} = \dfrac{100\ A_{k\gamma}}{A_{k\beta} + A_{k\gamma}} = \dfrac{100\ (A_{k\alpha} - A_{k\beta})}{A_{k\alpha}}$
- d = per cent by weight of the dust within a size interval
- d_k = per cent by weight of the dust within the size interval $k = \dfrac{100\ A_k}{A}$
- D = cumulative per cent by weight less than stated size $= 100 - R$
- R = cumulative per cent by weight greater than stated size $= 100 - D$
- M_g' = geometric-mean particle size, microns
- b = experimental parameter
- n = experimental parameter
- v = flue-gas velocity, also dust-particle velocity, fps
- V, V_g, V_c = dust-particle velocity orthogonal to direction of flue-gas velocity, fps
- ρ = flue-gas density, lb per cu ft
- η = flue-gas viscosity, lb per ft sec
- δ = dust-particle density, lb per cu ft
- δ_g = geometric standard deviation
- g = acceleration due to gravity, ft per sec per sec
- h, h', h'', w, l, r = dimensions of settling chambers, centrifugal concentrators, and cyclone removers, ft
- P, F_g, F_c = forces acting on dust particle, lb
- p = per cent of flue gas from which dust is completely removed
- s = surface toward which dust separates
- U = number of revolutions of flue-gas stream in cyclone remover
- $1, 2, 3 \ldots w$ = subscripts designating a series of definite consecutive size intervals covering the entire range of sizes from $\mu = 0$ to $\mu = \infty$
- e = Napierian base

Equations for Combining Size Frequency and Size Efficiency

$$\phi = \lambda_1 d_{\alpha 1} + \lambda_2 d_{\alpha 2} + \lambda_3 d_{\alpha 3} + \ldots + \lambda_w d_{\alpha w} \ldots\ldots [1]$$

$$\phi = \frac{1}{\left[\dfrac{d_{\gamma 1}}{\lambda_1} + \dfrac{d_{\gamma 2}}{\lambda_2} + \dfrac{d_{\gamma 3}}{\lambda_3} + \ldots + \dfrac{d_{\gamma w}}{\lambda_w}\right]} \ldots\ldots [2]$$

$$\phi = (Y + 1)/Y \ldots\ldots [3]$$

---

[1] Engineer, Air Pollution Survey, New York City Health Department. Jun. A.S.M.E. Mr. Stern was graduated from Stevens Institute of Technology with an M.E. degree in 1930, and after graduation remained at Stevens Institute as research assistant to E. H. Whitlock in the division of smoke-abatement research of the mechanical-engineering department. He received his M.S. degree from Stevens Institute upon completion of the research program in 1933. After an interval of two years in engineering appraisal work for the J. G. White Engineering Corp., and independently for the New York Times Company, he resigned in 1935 to organize the present air-pollution survey program for the New York City Health Department.

Contributed by the Fuels Division for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until July 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

where $$Y = \left[\frac{\lambda_1 d_{\beta_1}}{1-\lambda_1} + \frac{\lambda_2 d_{\beta_2}}{1-\lambda_2} + \ldots + \frac{\lambda_w d_{\beta_w}}{1-\lambda_w}\right]$$

$$d_{k\alpha} = \frac{(1-\phi)}{(1-\lambda_k)}\, d_{k\beta} = \frac{\phi}{\lambda_k}\, d_{k\gamma} \ldots\ldots\ldots\ldots [4]$$

$$d_{k\beta} = \frac{(1-\lambda_k)}{(1-\phi)}\, d_{k\alpha} = \frac{\phi\,(1-\lambda_k)}{\lambda_k\,(1-\phi)}\, d_{k\gamma} \ldots\ldots\ldots [5]$$

$$d_{k\gamma} = \frac{\lambda_k}{\phi}\, d_{k\alpha} = \frac{\lambda_k\,(1-\phi)}{\phi\,(1-\lambda_k)}\, d_{k\beta} \ldots\ldots\ldots\ldots [6]$$

Calculation of Separation and Removal Efficiency

Equations [1], [2], and [3] allow the calculation of the overall efficiency of separation from size frequency and size efficiency, provided the latter is known for the entire range of sizes existing in the dust. Equations [4], [5], and [6], allow the calculation of unknown size frequency of dust at either the α, β, or γ location, (entering the unit in suspension, leaving the unit in suspension, or separated in the unit) from the size frequency of the known one of these three conditions and size efficiencies for the entire size range of the entering suspended dust. The value of ϕ for use in the latter three equations may be calculated from one of the first three equations.

Of the first three equations, Equation [1] is the simplest and the most useful for design purposes. It is possible to effect a further simplification by arbitrarily varying the limits of the consecutive size intervals, 1, 2, 3 . . . . w, so that all values of d_α are the same. That this can be done is evidenced by the fact that the sum of all values of d_α, from 1 to w, inclusive, must be 100 per cent. Therefore, dividing 100 per cent by the desired number of equal values of d_α will give the per cent of the total dust weight included in each interval. Thus, if it is desired to have ten equal intervals, each value of d_α will be 10 per cent. Under these circumstances w is 10 and Equation [1] will factor as

$$\phi = 0.10\,(\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \lambda_5 + \lambda_6 + \lambda_7 + \lambda_8 + \lambda_9 + \lambda_{10}) \ldots [7]$$

In Equation [7], λ_1 is the efficiency of separating dust of the size interval corresponding to the range of R between 0 per cent and 10 per cent, which may be considered equivalent to the efficiency of separating dust of the size corresponding to R = 5 per cent, etc. So that when values of λ for the particle sizes corresponding to each of the following values of R equal to 5, 15, 25, 35, 45, 55, 65, 75, 85, and 95 per cent are added, and the sum multiplied by 0.10, the value of ϕ is calculated. This method would be equally valid had the value of d_α been chosen so as to make w any number other than 10, as, for instance, 5 or 20. However, from a practical point of view, five values are too few for analytical accuracy, and twenty are too many for graphical accuracy.

The removal efficiency of a unit in the flue-gas path will equal the separation efficiency ϕ only if conditions in the unit are such that the dust separated is removed from the flue-gas path as rapidly as it separates out of the flue gas. If the unit has no provision whatsoever for the removal of the separated dust, its removal efficiency must be zero regardless of how high its separation efficiency may be, because with no provision for removing the separated dust, the only possible result is for the separated dust to pile unremoved and unremovable up to such a height that the flue gases must re-entrain the dust to keep the flue-gas path open. Instead of continuous removal of the dust as noted previously, the intermittent removal of separated dust by the use of hoppers, into which the dust separates and from which it is removed at intervals frequent enough to avoid piling up beyond the hopper top into the flue-gas path, may be provided and equivalent results obtained. In intermediate cases where the removal system is inadequate to handle the quantity of dust separated, it is possible to have a removal efficiency lower than the separation efficiency, but greater than zero. The preceding calculations have been based solely upon size frequency and size efficiency, both of which vary with the rate of combustion of fuel in the furnace, causing removal efficiency to vary with rating.

Experimental data on size efficiency and size frequency obtained at several ratings during the same series of tests is subject to an important source of error caused by the lapse of time after changing the rating before a steady state is reached. This lapse is generally greater than that necessary to bring combustion conditions to a steady state at the new rating, and is caused by the piling up of dust at such places as on the floor of horizontal ducts, on ledges, and in hoppers. In a straight rectangular horizontal duct, gas velocity is proportional to rating. However, any piling up of dust on the floor of the duct decreases the cross-sectional area available for gas flow and thus increases gas velocity for the same rating as compared with a dust-free duct. Thus, the piling up of dust on the duct floor has the same effect on velocity as increasing the rating, and contrariwise, any action of flue gases passing over a pile of dust in re-entraining some of the dust in the gas will tend to decrease the height of the pile, increase the cross-sectional area available for gas flow and decrease the gas velocity in the same manner as a decrease in rating. Since with other factors remaining the same, the lower the gas velocity, the greater will be the piling up—and the higher the velocity, the greater will be the re-entrainment—it is apparent that there will be in a given duct a critical velocity for each rating at which re-entrainment will balance piling up, and that this velocity will occur after the dust has piled up in the duct to a definite height for each rating. Beyond that height re-entrainment will balance deposition, but the decrease in cross-sectional area and the increased gas velocity will increase the draft necessary to move the flue gas through the duct over that of a dust-free duct. An increase of rating will re-entrain dust and a decrease of rating will pile up dust until the critical velocities are all established for their respective ratings. Thus, during the interim following a change of rating, until critical velocities are all established, the instantaneous dust loadings, sizings and efficiencies will be considerably different from those after the steady state has been reached. Therefore, it is important that the values which are used in these calculations be steady state values.

Starting with the knowledge of the quantity and size frequency of dust leaving the furnace, and the size-efficiency characteristics of each unit in the flue-gas path, it is possible by means of a step-by-step calculation to calculate, first the quantity and size frequency of the dust leaving the first unit in the flue-gas path and entering the second unit; then, that leaving the second unit and entering the third; and so on to that leaving the next to last unit and entering the last one, which in this case would be the stack. If it is then possible to perform similar calculations for the stack, the result will be the quantity and size frequency of dust emitted to the atmosphere.

It should be obvious from the preceding considerations, that dust-emission and separation problems in fuel-burning equipment are susceptible of rational analysis and simple calculation, provided there is available to the person making the calculations the following experimental data:

(a) The quantity and size frequency of dust leaving fuel-burning furnaces at various ratings.

(b) The size efficiencies of all units in the flue-gas path experimentally determined against dusts of similar particle density and particle shape to that for which the calculation is to be made.

Methods of Analyzing Size-Frequency Data

Size-frequency analyses of dust determine experimentally the relationship existing between d and μ by means of sieving, sedimentation, elutriation, microscopic sizing or any combination of these methods. These experimental data are best subject to analysis by the use of a tabular form such as Table 1, from which can be plotted a distribution curve, such as shown in Fig. 1, which for a normal dust, is skewed as shown. Experience has proved that plotting these data on semilogarithimic paper serves to remove the skewness to a marked degree, so that plotting the cumulative percentage by weight, R, against μ on a logarithmic scale yields a curve, as shown in Fig. 2, from which may be obtained the ten values of μ corresponding to the specified values of R needed for the determination of ϕ using Equation [7].

Loveland and Trivelli (1)[2] have analyzed many different

TABLE 1 EXPERIMENTAL DATA IN TABULAR FORM FOR FIGS. 1, 2, 3, AND 4

Bureau of Standards sieves		Size in microns, μ	Dust per cent by weight, d	Per cent greater than stated size R	Per cent less than stated size D
on	10	2000	2	2	98
on	20	840	8	10	90
on	40	420	20	30	70
on	60	250	25	55	45
on	80	177	15	70	30
on	100	149	11	81	19
on	200	74	8	89	11
on	325	44	6	95	5
through	325	0	5	100	0

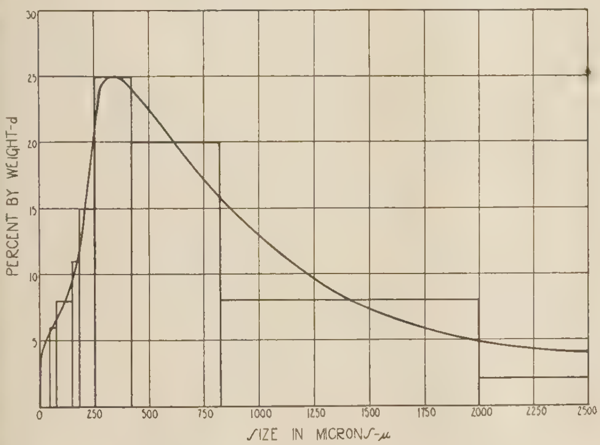


Fig. 1 Size-Frequency Distribution on Rectangular Coordinates of Dust Described in Table 1

methods whereby mathematical expression may be given to curves of the type shown in Figs. 1 and 2, with particular emphasis on expressions of sufficient simplicity that the parameters governing the expression would be useful as explicit constants for comparison and study. They discuss particularly the application of formulas developed by analysis of the relationship of the empirical distribution to that of "the normal" La Place-Gaussian law. Hatch (2, 3) and Choate (2) showed the usefulness of one of this type of expression that had been previously used by Hazen (4) and others. It is the logarithmic normal probability relationship

$$R_1 = \int_{\mu=\infty}^{\mu_1} \left[\frac{100}{\log \delta_g \sqrt{(2\pi)}} e^{-(\log \mu - \log M_g')^2/2\log^2 \delta_g} \right] d\mu. . [8]$$

Their method involves the plotting of R-μ data on logarithmic-probability paper, shown in Fig. 3; the drawing of a straight line through the plotted points, and calculating two parameters of the straight line; M_g', the geometric mean, which is the value of μ when $R = 50$ per cent, and δ_g the geometric standard deviation, which is the ratio of the value of μ for $R = 15.87$ per cent to the value of μ for $R = 50$ per cent. Since probability coordinates are symmetrical about the line for $R = 50$ per cent, δ_g also is the ratio of the value of μ for $R = 50$ per cent to the value of μ for $R = 84.13$ per cent. This method has been previously applied to cinders and fly ash by the author (5).

It is obvious that if the data plotted on logarithmic-proba-

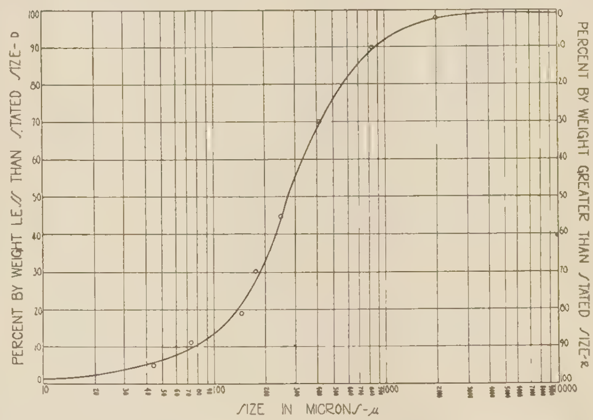


Fig. 2 Cumulative Size-Frequency Distribution on Semi-logarithmic Coordinates of Dust Described in Table 1 and Plotted in Fig. 1

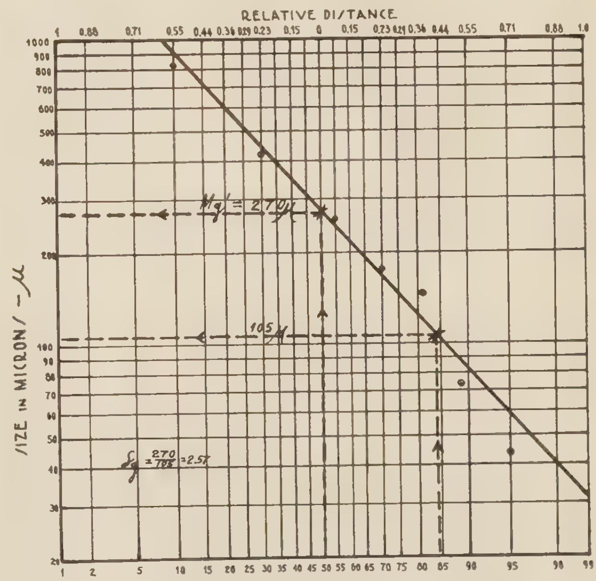


Fig. 3 Cumulative Size-Frequency Distribution on Logarithmic-Probability Coordinates of Dust Described in Table 1 and Plotted in Figs. 1 and 2

(The dotted lines are those necessary for the calculation of M_g' and δ_g.)

bility paper do not plot as a substantially straight line, they do not obey Equation [8], in which event M_g' and δ_g are meaningless and should not be calculated. The simplest method of using the parameters M_g' and δ_g to reconstruct the R-μ curve is to utilize a sheet of logarithmic-probability paper. First locate the point $\mu = M_g'$, $R = 50$ per cent; then the point $\mu = M_g'/\delta_g$, $R = 84.13$ per cent; then draw a straight line through these points. From this straight line, values of μ corresponding

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

TABLE 2 VALUES OF LOG LOG (100/R)

R	$\log\log\left(\frac{100}{R}\right)$	R	$\log\log\left(\frac{100}{R}\right)$	R	$\log\log\left(\frac{100}{R}\right)$	R	$\log\log\left(\frac{100}{R}\right)$
0.01	10.6021–10	16.0	9.9009–10	48.0	9.5035–10	80.0	8.9863–10
0.1	10.4771	18.0	9.8720	50.0	9.4785	82.0	8.9345
0.5	10.3619	20.0	9.8445	52.0	9.4533	84.0	8.8802
1.0	10.3010	22.0	9.8180	54.0	9.4275	86.0	8.8169
1.5	10.2610	24.0	9.7922	56.0	9.4009	88.0	8.7435
2.0	10.2302	26.0	9.7672	58.0	9.3740	90.0	8.6599
3.0	10.1827	28.0	9.7426	60.0	9.3462	91.0	8.6128
4.0	10.1455	30.0	9.7184	62.0	9.3172	92.0	8.5587
5.0	10.1143	32.0	9.6945	64.0	9.2873	93.0	8.4969
6.0	10.0870	34.0	9.6707	66.0	9.2565	94.0	8.4297
7.0	10.0625	36.0	9.6471	68.0	9.2243	95.0	8.3503
8.0	10.0402	38.0	9.6235	70.0	9.1903	96.0	8.2528
9.0	10.0194	40.0	9.5998	72.0	9.1544	97.0	8.1238
10.0	10.0000	42.0	9.5761	74.0	9.1163	98.0	7.9345
12.0	9.9642	44.0	9.5521	76.0	9.0799	98.5	7.8106
14.0	9.9314	46.0	9.5279	78.0	9.0330	99.0	7.6356

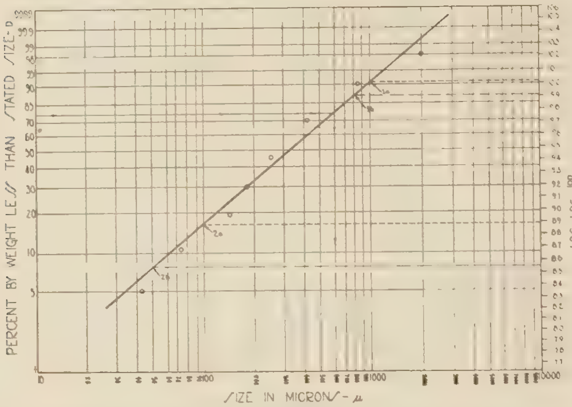


Fig. 4 Cumulative Size-Frequency Distribution on Log μ — (Log Log 100/R) Coordinates of Dust Described in Table 1 and Plotted, in Figs. 1, 2, and 3

(The dotted and dashed lines are used in the calculation of Table 3 by the simple and general methods, respectively. The solid line with arrows shows that the corresponding value of μ for D = 75 is 600 microns. This is to be compared with the similar result obtained by the use of Fig. 5.)

to R = 5, 15, 25 .... 95 per cent may be read directly for use in Equation [7].

Rosin and Rammler (6) have recommended an empirical expression for use instead of Equation [8]. It is

$$R = 100e^{-b\mu^n} \qquad \text{[9]}$$

They state: "It proved to be applicable without exception to cement, gypsum, magnesite, clay, dye stuffs, pulverized coal, in short, to all powdered materials of practical importance, down to the region of the very finest particles which could only be classified by sedimentation, as well as to the numerous methods of grinding employed such as sieveless tube mills with wet and dry grinding; both continuous and batch grinding, air-swept tube mills, centrifugal mills (Fuller and Raymond mills), with sieve and air separation, ring-roll mills (Rema and Mexican mills), impact mills of varied construction, and finally air-jet mills. In nearly every case the discrepancies between calculated and measured values are not more than 1 to 2 per cent of the total weight, seldom 3 per cent or more, and therefore, lie within the limits of accuracy of the methods of analysis employed (sieving, air elutriation, water elutriation and sedimentation).

"It is thus possible to state the law: The exponential $R = 100\, e^{-b\mu^n}$ is a universal law of size distribution valid for all powders, irrespective of the nature of the material and the method of grinding. The exponent n lies for the most part between 1 and 1.35. The parameter b varies over a much larger range."

In order to visualize the physical significance of the experimental parameters, n and b, it is necessary to note that the distribution curve in Fig. 1 shows a maximum, and the cumulative size-frequency curve in Fig. 2 shows a corresponding point of inflection. Rosin and Rammler (6) have shown that the maximum on the distribution curve and the point of inflection on the cumulative curve are possible only with $n > 1$. When $n = 1$, the maximum occurs at a particle size of zero microns, and as n increases the maximum occurs at increasingly larger particle sizes, obeying the equation

$$\mu_{\max} = \sqrt[n]{\left(\frac{n-1}{bn}\right)} \qquad \text{[10]}$$

Values of n less than 1 have no real maxima, therefore define impossible distributions.

By twice taking logarithms of Equation [9], Equation [11] is obtained

$$\log\log 100/R = n\log\mu + (\log b + \log\log e) \qquad \text{[11]}$$

from which it may be seen that a linear relation exists between [log log (100/R)] and log μ, with the parameter n as the slope, and the expression (log b + log log e) as the intercept. Therefore on coordinates such as shown in Fig. 4, having uniform increments of [log log (100/R)] as shown in Table 2 as ordinates, Equation [9], expressing the relationship between R and μ will plot as a straight line, and n and b will completely describe the size frequency of a dust which fits these coordinates, just as M_g' and δ_g describe a dust fitting logarithmic-probability coordinates, since only one straight line can be drawn having a particular set of parameters. Values may be determined beyond the range of the experimental data on either of these coordinates by extrapolation, using a projection of the straight line.

It is preferable to first plot experimental data on the [log log(100/R): log μ] coordinates, then fit the best straight line to these points, and last, to pick two points from that straight line for use in calculation. The reason for this preferential procedure is that the choice of any two experimental points not falling exactly on the line implies that the straight line goes through these two points, which, for the typical analysis plotted as Fig. 4, is obviously not the case. When these two points, whether experimental or from the straight line, are substituted in the two following equations, using Table 3, n and b may be readily calculated. These equations are

$$n = \frac{\log\log(100/R_1) - \log\log(100/R_2)}{\log\mu_1 - \log\mu_2} \qquad \text{[12]}$$

$$b = \text{antilog}\,[\log\log(100/R_1) - n\log\mu_1 - \log\log e] \qquad \text{[13]}$$

Use of these equations is simplified if points are picked from the straight line only at values of μ which are whole powers of 10 so that the resulting logarithms of μ become integers. If the

TABLE 3 CALCULATIONS OF THE CONSTANTS n AND b

		Simple method	General method
μ_1		1000	800
μ_2		100	50
$\log\log\left(\frac{100}{R_1}\right)$	A	10.020	9.910
$\log\log\left(\frac{100}{R_2}\right)$	B	8.890	8.550
A-B	C	1.130	1.360
$\log\mu_1$	D	3.000	2.903
$\log\mu_2$	E	2.000	1.699
D-E	F	1.000	1.204
n	C/F	1.130	1.130
$n\log\mu_2$	G	2.260	1.920
$\log\log e$	H	9.638	9.638
$G + H$	I	11.898	11.558
$B + 10$	J	18.890	18.550
J-I	K	6.992	6.992
b	antilog (K)	0.000982	0.000982
n		1.130	1.130
b		0.000982	0.000982

Note: Two sets of values of R and μ were used in the calculations, as shown in Fig. 4. Points with subscripts a were used in the simple-method calculations, and points with the subscript b were used in the general-method calculation.

experimental points are scattered so that no representative straight line can be drawn through them, no attempt should be made to calculate parameters, because under these conditions the chosen exponential function evidently cannot be made to express the R-μ relationship implicit in the data.

A graphical means for the solution of Equation [9] can also be shown. Fig. 5 yields a series of simultaneous values of R and μ corresponding to any set of values of n and b. With the exception of the lines marked $R = 2$ and 98 per cent, the remaining ten lines allow the determination graphically of ten values of μ corresponding to $R = 5, 15, 25 \ldots\ldots 95$ per cent which were previously noted as necessary for the simplified calculation of ϕ using Equation [7].

It should be noted that where the 50 per cent size of any cinder or fly-ash sample is less than 74μ in the case of a screen analysis with 200 mesh as the finest screen (43μ with 325 mesh as the finest screen) no data can be available from the screen analysis for the other 50 per cent or more by weight of the dust. Practically all fly-ash and suspended-cinder samples are in this category. Cinders that separate out of flue gas are coarser, however, and generally have more than 50 per cent by weight

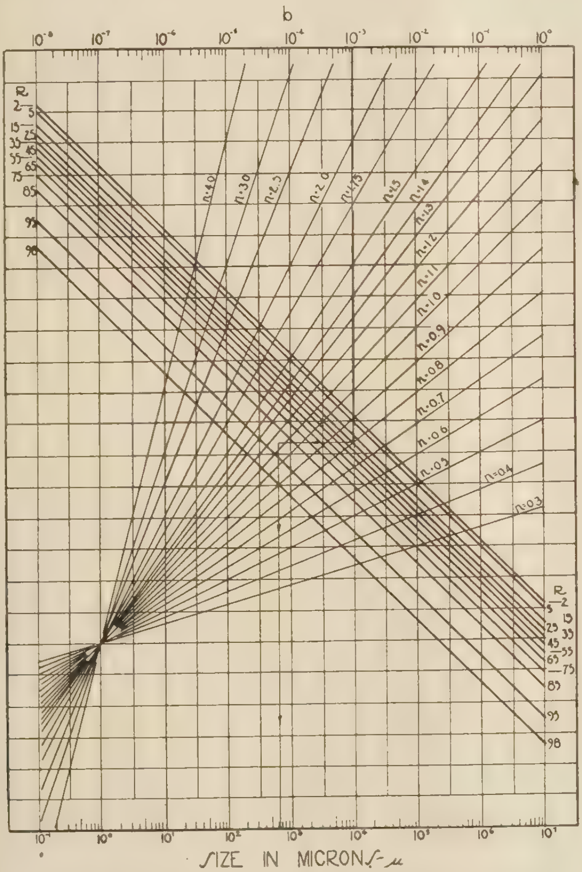


Fig. 5 Chart for Graphical Solution of $R = 100e^{-b\mu n}$

(From the value of b on the top axis drop a vertical line to the value of R on the parallel diagonal lines, then project a horizontal line to the value of n on the diagonal fan of the lines, then drop a vertical line to the unknown value of μ on the bottom axis. The values of b and n illustrated are $b = 0.000982$ and $n = 1.130$ from Table 3. The value of R is 25 ($D = 75$) and the corresponding value of μ is 600 microns, the same as obtained in Fig. 4.)

of particles with diameters $> 43\mu$, therefore, screen analyses of them generally yield sufficient points for accurate plotting. A study of 46 such sieve analyses of cinders from hoppers of stoker-fired boilers showed the following variability of n: 92 per cent of the samples between 0.88 and 2.23; 70 per cent between 1.07 and 1.99; and 45 per cent from 1.50 to 1.99. The variability of b was: 91 per cent between 0.0073 and 0.0000001; 82 per cent between 0.0073 and 0.0000012; and 45 per cent from 10^{-4} to 10^{-5}. Even the 18 per cent of these 46 dusts having values of n less than 1, the extrapolations of which are evidently not correct, nevertheless yield parameters which do describe the known portion of the distribution and do allow reasonably exact interpolation.

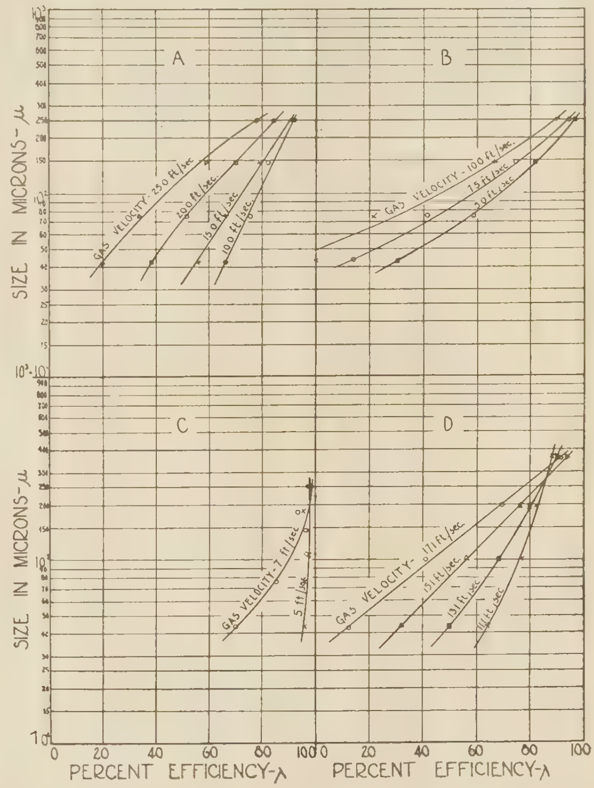


Fig. 6 Experimental Size-Frequency Characteristics for Actual Installations of Cinder and Fly-Ash Removers

Experimental Determination of Size Efficiency

The variation of λ_k with temperature, pressure, density, and viscosity within the small range possible in the case of flue gas is negligible compared with the variation with respect to particle size and flue-gas velocity. Size-efficiency characteristics of four typical dust removers A, B, C, and D are shown in Fig. 6. Removers B and C are of the dry mechanical type, whereas removers A and D are of the water-level impingement type without sprays or wetted surfaces. In all of these units, efficiency falls off with decreased particle size. Also in all of them, removal is centrifugal, and should theoretically have an increased removal efficiency with increased gas velocity. However, in each, the efficiency falls off with increasing flue-gas velocity for particles smaller than 200μ. In the case of remover C, efficiency increases with velocity over 200μ; in remover D, efficiency increases with velocity for particle sizes over 350μ; in remover A, the particle size beyond which efficiency increases with velocity is 450μ; while in remover B there is no evidence of this occurring at any particle size.

Thus, the velocity-efficiency characteristic is according to theory for the larger-sized particles, but not for the finer ones.

From considerations such as these, it should be obvious that only experimentally determined values of size efficiency should be used for design purposes.

Graphical Methods for Determination of Removal Efficiency

Figs. 2, 3, 4, or 5, may each be combined with an experimentally determined size-efficiency curve such as Fig. 6 so that a complete graphical solution of ten values of λ needed for the solution of Equation [7] may be effected on but one chart. The combination of charts of the type of either Figs. 2, 3, or 4 with one of the type of Fig. 6 allows the graphical solution of ϕ for one particular unit and one particular dust. However, to allow the graphical solution of the efficiency of one particular unit against any possible dust, it is necessary to combine a chart of the type of Fig. 6

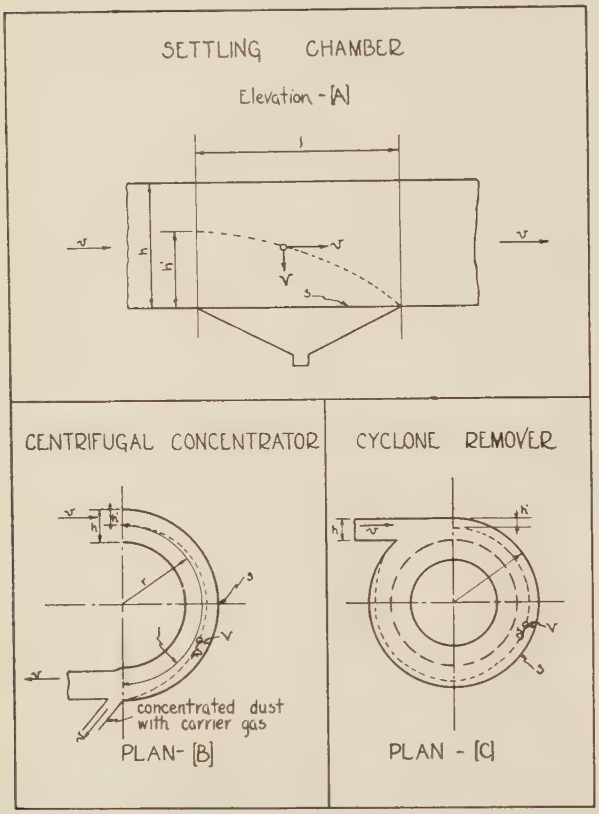


Fig. 7 Theoretical Motion of Dust Particle in (A) Settling Chamber, (B) Centrifugal Separator, and (C) Cyclone Remover

(A is an elevation view; B and C are plan views; V is orthogonal particle velocity. v is both particle and flue-gas velocity. h, h', l, and r, are the physical dimensions of the unit.)

with Fig. 5. Charts of wholly experimental origin combining Fig. 2 with Fig. 6 have already been put to use to solve design problems. In the author's opinion charts combining with Fig. 6 either Fig. 4 or Fig. 5, or the graphical representation of some other equation that may be later shown to more accurately fit experimental data, deserve a trial to determine whether or not they are as useful as they appear at present.

Theoretical Derivation of Size Efficiency

Theoretical derivations are based upon many simplifying assumptions, such as the absence of eddy currents; the absence of turbulent re-entrainment of separated dust; and the presence of a uniform distribution of dust and gas velocity. A theoretical approach such as the following one, however, does provide a rational basis for the interpretation of experimental data.

If flue gas passes through a unit at velocity v, so that the dust within the size interval k suspended in p per cent of the gas is completely separated in the unit, and the dust within the same size interval, suspended in the remaining $(100—p)$ per cent remains in suspension, the size efficiency of the unit for size interval k must equal p per cent. Under the assumed conditions of uniform gas flow, p per cent of the gas will flow through a cross-sectional area of phw, while the remainder of the gas flows through an area of $(100—p)\,hw$. If it be assumed that the gas flows in two nonmixing strata, both of width w, one will have a height $h' = ph = \lambda_k h$, and the other $h'' = (100—p)\,h = (100—\lambda_k)h$. Thus, it is obvious that

$$\lambda_k = h'/h \qquad [14]$$

Every particle of size interval k, in gas strata h' must thus reach removal surface s, as shown in Fig. 7, within length l, because under the assumed conditions, a particle not reaching s, cannot be considered as removed from the gas stream. Similarly, none of the particles in stratum h'' may reach s within the distance l, although they may reach it at any point beyond l. Therefore, a particle on the boundary between stratum h' and stratum h'' must just reach the removal surface at distance l. The time taken by one of the latter particles to travel distance l will be l/v seconds, assuming that the particle travels at the same velocity as the flue gas. The time taken for the same particle to travel distance h', orthogonal to the direction of v, will be h'/V seconds where V is the orthogonal particle velocity. These two times must be equal, so that

$$h' = \frac{Vl}{v} \qquad [15]$$

and, substituting in Equation [14]

$$\lambda_k = V\left(\frac{l}{vh}\right) = f(\mu)\left[\frac{l}{vh}\right] \qquad [16]$$

since, as will be later demonstrated, all other conditions remaining constant, V is a function of μ.

Graphical Determination of Theoretical Size Efficiency

Equation [16] may be solved graphically by the use of Fig. 8 which consists of a series of V-λ characteristics for various values of the ratio (l/vh), and a series of V-μ characteristics for various combinations of forces causing separation both plotted on the same coordinates, so that a value of λ_k may be obtained directly from a corresponding value of μ on but one chart. Fig. 8 thus represents the theoretical λ_k-μ relationship just as Fig. 6 represents the experimental one.

The ratio (l/h) will, in general, vary between 1 and 25, depending upon design conditions. The usual range for v is from 1 to 100 fps, so that the normal range of the ratio (l/vh) will be from 0.01 to 25. When $\lambda_k = 1$ and $(l/vh) = 0.01$, $V = 100$ fps; whereas when $\lambda_k = 1$ and $(l/vh) = 25$, $V = 0.04$ fps. The effect of a higher value of V in both these cases would be to make $\lambda > 1$ which is an impossibility meaning that 100 per cent separation is effected in a distance less than l. In the case of gravity settlement, $V = 0.04$ for a particle of about 15μ and $V = 50$ for a particle of about 2000μ. Although beyond 2000μ, particulate matter can scarcely be called dust, $V = 100$ for a hypothetical particle of $10{,}000\mu$.

Settling Chambers

Any horizontal run of duct or breeching such as that shown

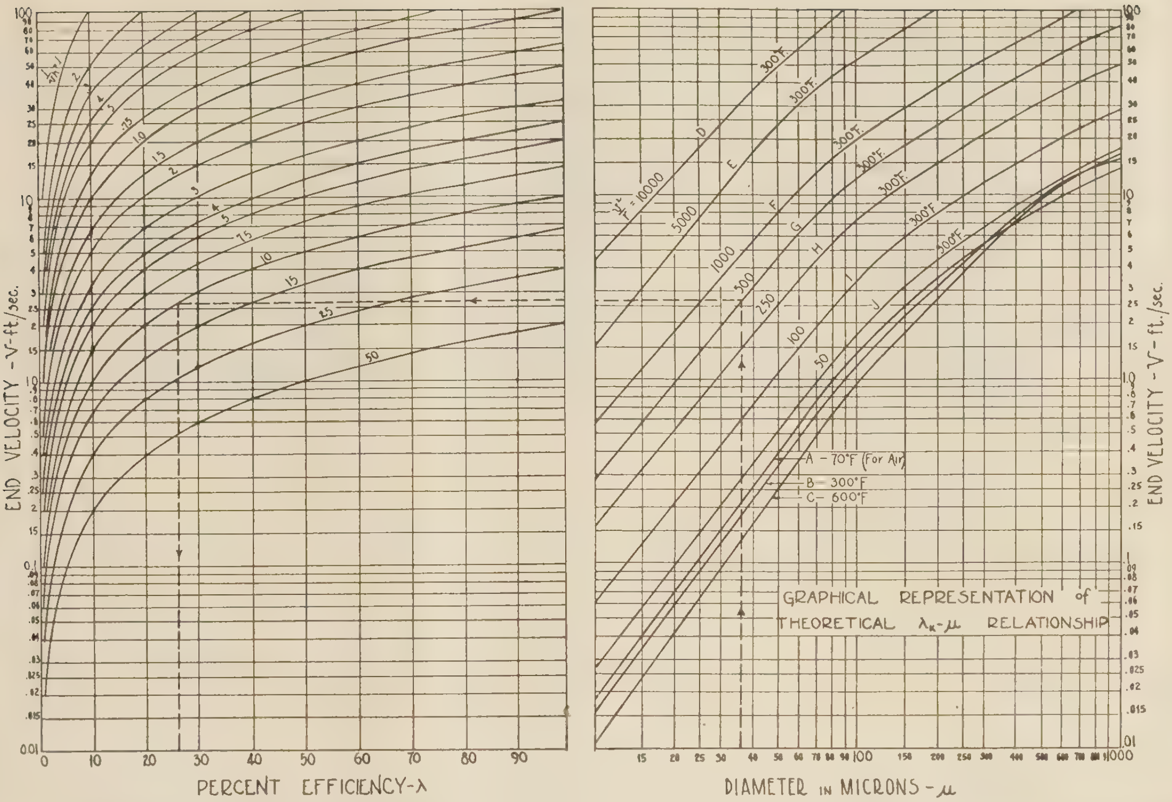


Fig. 8 Theoretical Size-Frequency Characteristics of Settling Chambers, Centrifugal Concentrators and Cyclone Removers
(The dashed line shows a typical calculation.)

in Fig. 7*A* will act as a dust remover if it is provided with hoppers for the continuous or intermittent removal of the separated dust. The ratio (l/vh) will be made up of v the average velocity; h the height of the duct; and l the distance from the beginning to the end of that portion of the duct provided with hoppers. The gravity-settling velocity V_g is obtained by solving for V after equating the force of the gas resisting particle motion

$$P = 9.84 \times 10^{-6} \frac{\pi\mu\eta V}{g}\left[1 + 0.14\left(\frac{\mu\rho V}{\eta}\right)^{0.7}\right] \ldots\ldots [17]$$

to the weight of the particle which is the force on the particle causing motion toward surface s. This force is

$$F_g = 5.88 \times 10^{-18}\,\pi\,\mu^3\,(\delta - \rho) \ldots\ldots\ldots\ldots [18]$$

Croft (7) has effected this solution of V for the range $\mu = 10^{-1}$ to $\mu = 10^4$ for air at 70 F and flue gas at 300 F and 600 F. These V_g-μ curves are reproduced for the range $\mu = 10$ to $\mu = 10^3$ as curves A, B, and C of Fig. 8.

In Equations [14] to [19], inclusive, particle density δ, gas density ρ, gas viscosity η, acceleration due to gravity g, velocities v and V, lengths l and h, and forces P and F are all in foot-pound-second units, but μ is in microns.

Centrifugal Concentrator

Any bend in a duct or breeching such as Fig. 7*B* will tend to concentrate dust toward its outer wall due to centrifugal force. If this outer stratum of flue gas containing the bulk of the dust is removed from the main stream of flue gas and its entrained dust completely separated in an auxiliary unit of equipment, the effect will be the same as if there had been a hopper built into the duct to remove the dust as soon as it reached removal surface s. In this case v and h have the same significance as in gravity settlement and l is the mean length of flue-gas path from the point where the bend starts to the point where the bend stops.

The force of gravity F_g on the particle shown in Fig. 7*B*, which is a plan view, is orthogonal to both v and V, and therefore must be neglected in calculating V. However, had Fig. 7*B* been an elevation view, the force of gravity would still have been neglected even though it is no longer orthogonal to V, both because its value is small compared to the centrifugal force, and because it acts in different directions with respect to surface s above and below the center line. The centrifugal settling velocity V_c is thus obtained by solving for V after equating Equation [17] to the centrifugal force on the particle causing motion toward surface s. The centrifugal force is

$$F_c = 35.5 \times 10^{-18} \frac{\pi\mu^3\,\delta v^2}{6\,gr} \ldots\ldots\ldots\ldots [19]$$

Assuming flue gas at 300 F, the V_c-μ relationship has been calculated for a number of different values of the ratio (v^2/r), and has been plotted as D, E, F, G, H, I, and J, in Fig. 8.

Cyclone Remover

The cyclone remover shown in Fig. 7*C*, is similar to the centrifugal concentrator except that the dust, after having concentrated on removal surface s falls by gravity into a hopper bottom integral with the cyclone, and secondly, that the gas makes several complete revolutions before entering the axial exhaust, so that distance l is indeterminate. Rosin, Rammler, and Intelmann (8) have attempted a theoretical solution of the cyclone

using an approach slightly different from that of Equation [16]. Their assumptions, however, are of use in this type of solution. These are that the stream of flue gas, which enters through a rectangular entrance duct of dimensions h and w, retains these two dimensions as it spirals unconstrained down the wall of the cyclone; that succeeding revolutions of this spiral are adjacent but do not mix; that the radius of the cyclone may be used as radius of curvature of this spiral; that the length of flue-gas path for one revolution of the spiral be the circumference of the cyclone; that there are a whole number of these revolutions U; and that the inlet gas velocity be considered to continue throughout the spiral.

Thus to obtain the ratio (l/vh), h is the width of the inlet duct, v is the velocity through the inlet duct, and $l = 2\pi rU$ where r is the radius of the cyclone and U is the number of revolutions of the gas in the cyclone. There is no rational method for estimating U, so that until experimental data can be correlated with theory a value of U from 2 to 4 seems reasonable. The value of V_c is obtained, as in the previous case of the centrifugal concentrator, from curves D, E, F, G, H, I, and J of Fig. 8.

It should be noted that the method for calculating cyclone efficiency as given by the author is at variance, in its assumptions with the vortex theory of cyclone collection. Vortex theory (the inverse relationship between gas velocity and radius, known to exist in cyclones) is neglected by assumptions of constant v and V. However, all attempts to incorporate this concept into these simplified methods of calculation have resulted in solutions too complicated to use.

Acknowledgment

The author wishes to acknowledge assistance in the preparation of this paper by Paul Hirschman, engineer, with Gibbs & Hill; and Meyer Berliner, assistant supervisor of the Air-Pollution Survey, New York City, Health Department.

BIBLIOGRAPHY

1 "Mathematical Methods of Frequency Analysis of Size of Particles," by R. P. Loveland and A. P. H. Trivelli, *Journal of the Franklin Institute*, vol. 204, July–December, 1927, pp. 193–214 and 377–389.

2 "Statistical Description of the Size Properties of Non-Uniform Particulate Substances," by T. Hatch and S. P. Choate, *Journal of the Franklin Institute*, vol. 207, January–June, 1929, pp. 369–387.

3 "Determination of Average Particle Size From the Screen-Analysis of Non-Uniform Particulate Substances," by T. Hatch, *Journal of the Franklin Institute*, vol. 215, January–June, 1933, pp. 27–37.

4 "Storage to be Provided in Impounding Reservoirs for Municpal Water Supply," by A. Hazen, Trans. A.S.C.E., vol. 77, 1914, paper 1306, pp. 1539–1640.

5 "The Measurement and Properties of Cinders and Fly-Ash," by A. C. Stern, *Combustion*, vol. 4, no. 12 and vol. 5, no. 1; June–July, 1933, pp. 35–46.

6 "The Laws Governing the Fineness of Powdered Coal," by P. Rosin and E. Rammler, *Journal of the Institute of Fuels*, vol. 7, October, 1933, pp. 29–36.

7 "The Calculation of the Dispersion of Flue Dust and Cinders From Chimneys," by H. O. Croft, Trans. A.S.M.E., vol. 57, 1935, paper FSP-57-1, pp. 5–10.

8 "Grundlagen und Grenzen der Zyklonentstaubung," by P. Rosin, E. Rammler, and W. Intelmann, *Zeit. V.D.I.*, vol. 76, no. 18, April 30, 1932, pp. 433–436.

Architect's Perspective Drawing of Springwells Station, Showing Major Plant Structures

The Springwells Station of the Detroit Department of Water Supply

By WILLIAM C. RUDD,[1] and BERNARD J. MULLEN,[2] DETROIT, MICH.

The Board of Water Commissioners of the City of Detroit anticipated the need of increasing the water-supply facilities for the city nearly 20 years ago and in the year 1919 ordered that engineering studies be made. As a result of these studies an additional water-supply system was authorized in 1924 at an estimated cost of $30,000,000. The project included a new river intake of 940 million gallons daily capacity, tunnels in sizes of 12 ft to 15½ ft diameter, about 12 miles long, a new pumping plant for 400 million gallons daily, filtration plant, and 16,500-kw steam-operated power plant. The new works were substantially completed in 1931 and placed in partial operation, but due to the depression, the plant was not placed in continuous service until 1935.

This paper discusses the various problems and engineering studies made in connection with the design and construction of a large modern water-works plant, with especial reference to the hydraulic and mechanical features of the pumping plant and the mechanical and electrical characteristics of the steam-operated power plant.

The pumping plant consists of raw-water pumps for delivering river water from the intake and tunnel system to the filter plant and also the filtered-water pumps to force water supply to the city distribution system. All pumps are housed in one building about 400 ft long by 100 ft wide. There are 26 centrifugal pumps varying in size from 7 to 60 million gallons daily each. The pumps are driven by synchronous and induction motors.

Power for the pump motors is produced in a steam turbogenerator plant, exclusive of a small portion that is secured from a central-station source. The power plant is adjacent to the pumping plant and consists of two 5000-kw and three 500-kw steam turbogenerators, two 90,000-lb per hr steam boilers and related equipment, together with a 5000-kw transformer for central-station power.

This paper deals with purchase of pumping and power-plant equipment secured in competitive bidding, with some of the major equipment secured on evaluated bids and with bonuses and penalties applied to contractor's guarantees. The paper also outlines the results of field acceptance tests for pumps, turbines, and boilers and gives the resulting bonuses and penalties applied to the various contracts. The paper also discusses the general plant-operating economies for a one-year period.

The Springwells Station of the Detroit Department of Water Supply was considered in the early 1920's as a means of augmenting the water supply of a rapidly increasing population in Detroit and vicinity. The phenomenal growth of the automobile industry together with new manufacturing plants attracted by the unique industrial conditions of this area, all served to focus attention upon the need for enlarged water-supply facilities.

[1] Assistant Engineer Water System Construction (Power) of the Detroit Department of Water Supply. Mem. A.S.M.E. Mr. Rudd is a graduate of the University of Kentucky in mechanical engineering. He was formerly engaged as assistant engineer of water supply for the Louisville & Nashville Railroad Co., Louisville, Ky. He has been associated with the Detroit Department of Water Supply for the past 12 years.

[2] Chief Plant Engineer, Springwells Station of the Detroit Department of Water Supply. Mem. A.S.M.E. Mr. Mullen is a graduate of the University of Michigan in civil engineering. He was formerly employed for five years with the Detroit Edison Company. He has been associated with the Detroit Department of Water Supply for 16 years, the last two years in his present capacity.

Contributed by the Hydraulics and Steam Power Divisions for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until July 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Until 1931, when the Springwells Station located in the western section of Detroit was placed in partial operation, the Detroit area was supplied only from the Water Works Park Station situated on the east side of the city close to the Detroit River. Proposals considered for future needs also include the possibility of locating a third pumping and filtration station in the northeast section of the city.

Three sources of raw-water supply were considered, namely, Lake Huron, Lake St. Clair, and the Detroit River. The last-named source is already serving the existing Water Works Park Station. Because of the extremely high cost of constructing

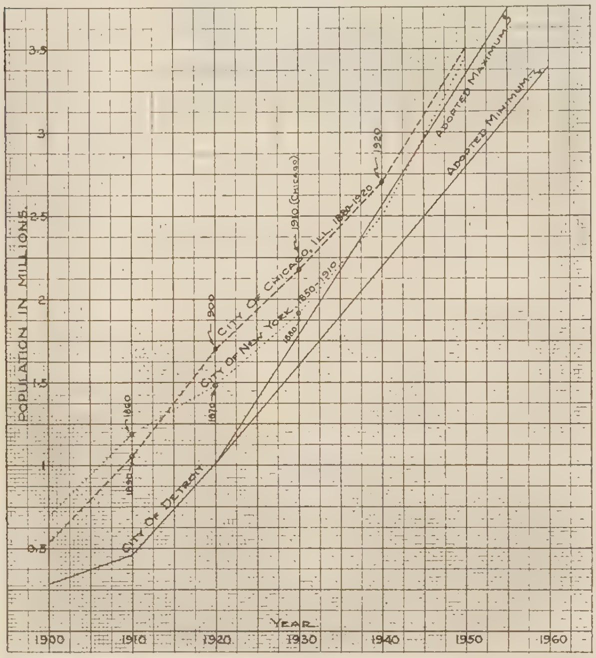


Fig. 1 Shows Estimated Population Curves for Detroit for 1900–1960, and Comparison With Chicago 1880–1920, and New York City 1850–1910

long connecting tunnels to the lakes and the increased pumping plants costs the head of Belle Isle in the Detroit River was chosen as the source of supply. This location was deemed adequate to supply the contemplated water requirements up to 1960, by which time shifting population and industrial changes might necessitate substantial revision in policy on plant extension. Studies of population growth in Chicago and other large cities indicated that the number of people in greater Detroit and the 300 square miles embraced by the water service might reach 3.4 millions by 1960, as shown in Fig. 1. The annual increase in water consumption corresponding to this growth and based upon a pumpage of 152 gal per capita daily, amounts to 10 or 12 million gallons per day (mgd) for each succeeding year.

The average annual consumption of water in the objective year, 1960, was estimated from these data at 520 mgd. Studies of the existing plant, modernized to increase its capacity, and of the sites chosen for the two new plants considered in conjunction with several other factors, showed that this average daily capacity of 520 mgd could be divided economically as follows: Water Works Park Station, 220 mgd; Springwells Station, 180 mgd; the future Northeast Station, 120 mgd. Estimates based on recorded daily-load curves and the full use of the Springwells site indicated that the raw-water pumping plant and filter plant should be designed for 135 per cent and the filtered-water pumping plant and distribution system should be designed for 180 to 190 per cent of the average daily water requirements.

The Springwells Station includes raw- and filtered-water pumping plant, filtration and electric-power-generating plants. Raw water flows by gravity from the Belle Isle intake through a tunnel extending under the City of Detroit to the inlet well of the station. A low-lift pumping plant takes water from this well and discharges it into two conduits leading under the power plant to the mixing chamber, coagulation basin, and the filter plant. Filtered water passes either to storage or to the suction of the high-lift pumps discharging into the distribution system. Fig. 2 is a diagrammatic layout indicating the flow pattern described later at greater length.

Several technical papers and articles describing some of the hydraulic- and civil-engineering features of the Springwells Station have already been published. The bibliography[3] included in this paper for convenience of those who wish to study design and operation further, lists these publications and others to which reference is made.

While the present paper gives a brief account of the hydraulic and civil-engineering features of the project, the primary purpose is: (*a*) To review the reasons for choosing motor-driven centrifugal pumps for both the high- and low-lift sections of the pumping station, giving an account of this equipment and its characteristic performance; (*b*) to describe the electrical generating plant built on the site, with provision for limited emergency service from a central-station supply; (*c*) to compare the expected performance of the station and its equipment with test results and with operating results obtained to the present time.

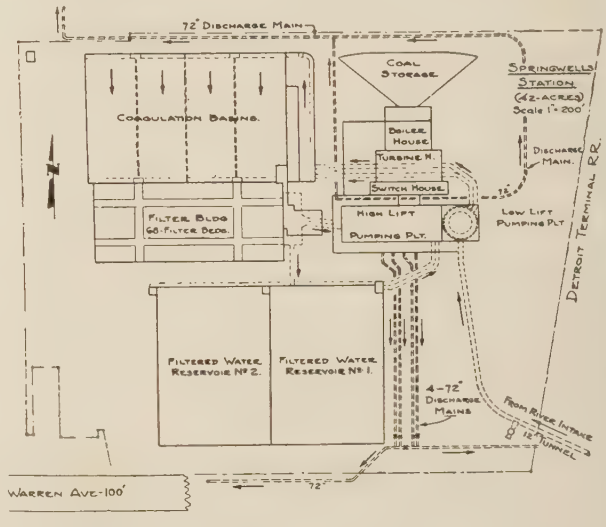


Fig. 2 Shows Flow of Water From River Intake to Springwells Station and Route of Raw and Filtered Water Through Various Plant Structures and Thence to Water-Distribution System

1 HYDRAULIC AND CIVIL-ENGINEERING FEATURES

The principal hydraulic and civil-engineering features of the plant are: (*a*) the river-water intake and tunnel to the screen chamber, (*b*) the land tunnels to the pumping station, (*c*) the low-lift plant, (*d*) the filtration plant, and (*e*) the high-lift plant feeding the city mains. Each of these features is deemed

[3] Numbers in parentheses refer to the Bibliography at the end of the paper.

sufficiently outstanding and pertinent to the mechanical design of the plant to be described at some length.

River-Water Intake

The intake consists of a stone and concrete structure and lagoon built at the head of Belle Isle in the Detroit River. The lagoon, intake, and river tunnel have been designed for a maximum capacity of 940 mgd, with an average flow of 700 mgd. The lagoon design was based on preliminary studies made on a model built to scale. Surveys and tests were also made in the Detroit River, with reference to pollution from Fox and Conners creeks. Low approach velocities tending to reduce troubles from frazil ice and also to produce a better supply of water were contemplated.

The lagoon has an entrance at the northeast, or upstream, end, a back channel to the south, and intake structure at the west end. The effective length of the lagoon is 2600 ft, the width about 200 ft at the mouth and 450 ft near the intake structure, and the depth about 28 ft (1, 2).[3]

Water from the lagoon is led into the intake structure through two shafts, one leading to the old 10-ft diameter river tunnel, placed in service in 1905 and the other to the new $15^1/_2$-ft diameter river tunnel about 4250 ft long terminating in the screen chamber in Water Works Park. The new tunnel was placed in service in 1931. The old brick-lined river tunnel is built in clay with its invert, i.e., the bottom inside, 66 ft below the river level; the new tunnel is concrete-lined, built in rock with its invert 181 ft below river level. An emergency water inlet from the river, independent of the lagoon, is connected to the intake structure. Emergency operation, controlled by a large float-operated poppet valve, occurs when the water level in the lagoon falls 12 or more in. below the river level.

Land Tunnels

The land tunnels, conveying water from the screen chamber in Water Works Park to Springwells Station, are about $10^1/_2$ miles long. From Water Works Park, a 14-ft diameter section extends approximately north about two miles to a junction well, where two connections are provided. One connection, 10 ft in diameter, for the future extension to the northeast, is blocked; the other ties into the 12-ft diameter section proceeding west to the Springwells Station. The tunnel, concrete-lined, was built in clay; and a large part of the work was done under compressed air. With a coefficient $C = 120$ in the Williams and Hazen formula, the tunnel capacity to the junction well is 570 mgd, and from there on, 350 mgd. The capacity of the future northeast extension is estimated at 220 mgd. The 14-ft section of the tunnel under 67 ft head of water at Water Works Park rises 25.7 ft to the junction well; the 12-ft section then declines 18.8 ft to the station. The invert of the tunnel is 93 ft below grade at the entrance to the low-lift plant (3).

Low-Lift Pumping Plant

The low-lift pumping plant, because of the depressed hydraulic grade line occasioned by the long tunnel from the river intake, required several novel features, among which were: (*a*) a deep pit for the low-lift pumps, (*b*) motor-driven centrifugal pumps in both the low-lift and high-lift plants, and (*c*) a combination of constant-speed and adjustable-speed motors of various sizes to take load fluctuations in an efficient manner. In order to appreciate the function and duty of these centrifugal pumps, as well as the reasons for selecting motor drives, a description of the hydraulic plant is given before reviewing the engineering studies made on the available pump drives.

Low-Lift Pumping-Plant Studies. The low-lift pumping plant, because of the difficult conditions already described, was the subject of intensive study. Twenty-one different schemes, all involving the use of centrifugal pumps, were investigated. The schemes are outlined below as typical examples of various methods studied to meet adverse conditions, namely, nine designs with vertical motor-driven pumps in a circular plant, four designs with horizontal motor-driven pumps, three designs with horizontal turbine-driven pumps in a circular plant, three designs of rectangular plants with both horizontal motor and turbine drive, and two special designs of cellular structures built up of independent shafts, each shaft containing a vertical motor-driven unit. The study reviewed also the problems involved in the several designs from the standpoint of construction

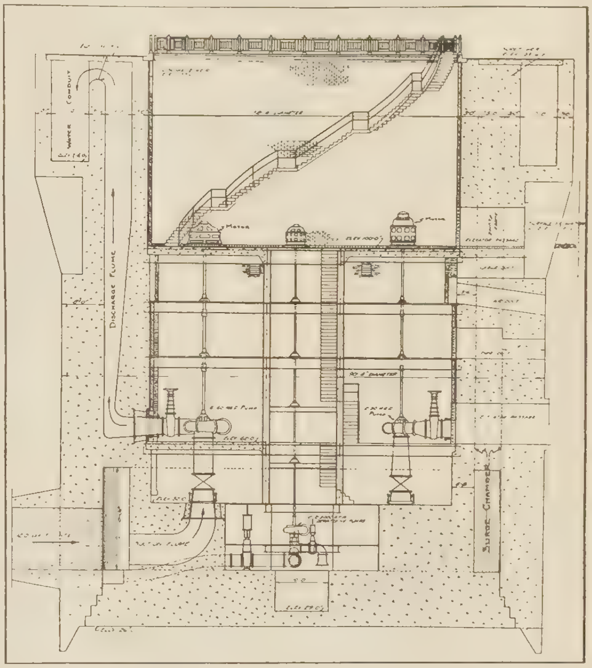


Fig. 3 Cross Section of Low-Lift Pumping Plant, Showing Location of Pumps, Discharge and Suction, and Surge Flumes

difficulties, water-surge adequacy, operating reliability, and cost.

Particular attention was given the relative reliability of the two practicable kinds of motive power, namely, steam and electricity. Because of cost, water turbines had been eliminated from consideration. The principal objections to the use of steam were that, since the turbines must be placed about 70 ft below finished grade, long vertical 8-in. feeder mains would be required for carrying 300-lb steam to the throttle; that the support of these mains introduced unusual structural problems; and that stresses arising out of pipe movement might result in joint failure. Further it was pointed out that although it is perhaps practicable to supply automatic-control equipment for the prompt closure of a broken header, the breakage of a main in a station so far below ground might result in serious injury or death to employees.

The reliability of electric motors, assuming that they were placed out of the reach of flooding, was limited only by the failure of the motors themselves or by the failure of the source of supply. The duplication of units was proposed to provide for the first contingency, and duplicate underground feeders from an adjacent power plant and a partial reserve supply from an independent source of power, for the second. The contingency of

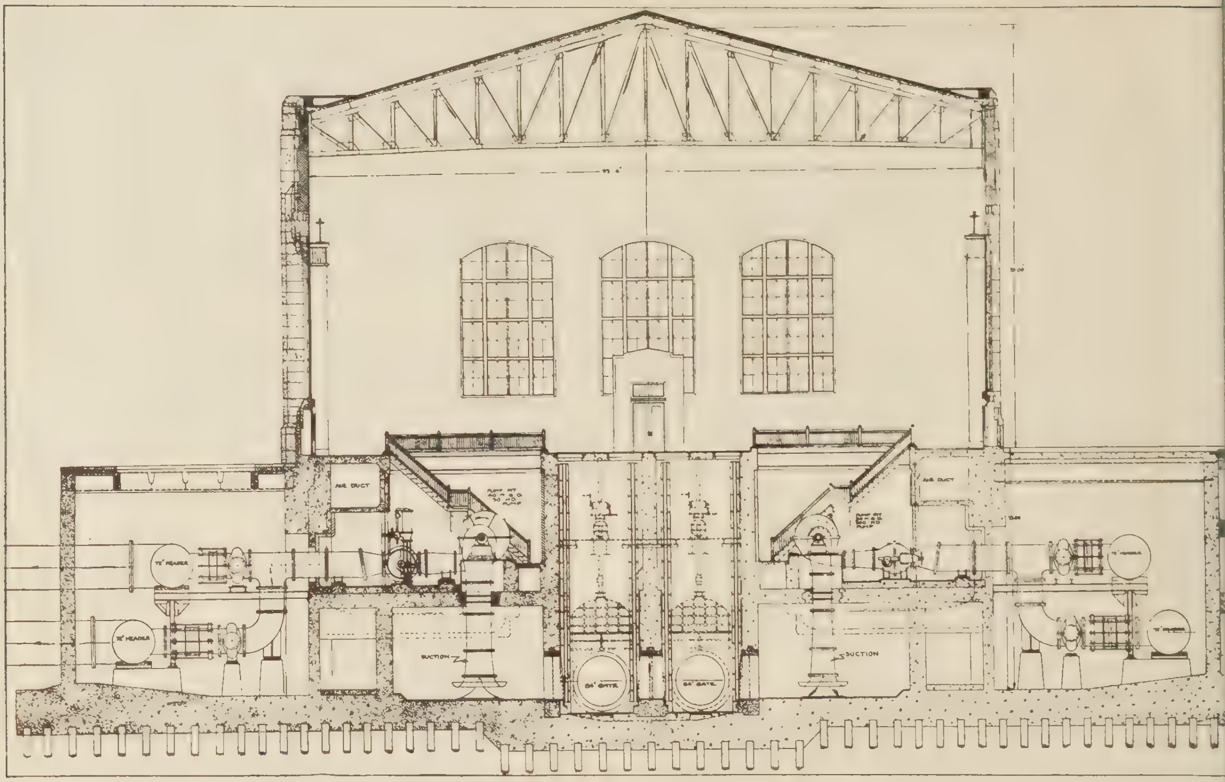


FIG. 4 CROSS SECTION OF HIGH-LIFT PUMPING PLANT, SHOWING LOCATION OF PUMPS AND PIPING

flooded motors was eliminated by the use of vertical units, with the motor floor placed above the level of the river. In the plant, as built, flooding of any sort has been reduced to the possibility of a broken pump casing, as the surge chambers are incorporated in the outside walls of the structure, and the pumps discharge up through vertical concrete conduits, also in the walls (4).

Low-Lift Pumping Plant. The low-lift pumping plant receiving river water from the tunnel previously described, is shown in cross-sectional elevation in Fig. 3. The circular well housing the pumping plant is 55 ft in diameter, and contains eight main-unit and two auxiliary motor-driven vertical centrifugal pumps. The total rated capacity of the plant is 435 mgd against a head of 50 to 60 ft. Main and auxiliary pumps are driven by motors of 750 hp, 350 hp, and 100 hp.

The pumps discharge into vertical flumes built between two concentric cylinders, with a separate flume for each main pump or eight in all. These flumes terminate in a weir, located in the top of a common conduit placed with its top at the main-floor level. Between the pump flumes there are eight open spaces running to the bottom of the substructure. These spaces serve as water-surge chambers. Since there is a weir connected to the water conduit at the top of each space, this design gives a spilling-type surge well. After the pumps were placed in service, test measurements of a surge were found to be close to predictions made from the model-test survey (5). The pumps located 40 ft below the motors driving them were so placed that the suction lift at maximum demand would not exceed a dynamic lift of 12 ft.

The pumps are equipped with hydraulically operated gate valves, controlled by electric-solenoid four-way valves. The gate valves on the discharge side are electrically interlocked with the control circuit of the motors. The control is such that while the pump can be started from the switchboard only, it can be stopped both at the switchboard or at the pumps. The two auxiliary pumps, arranged to pump from the tunnel or the low-lift pumping plant, can also pump out the tunnel for dewatering purposes.

FILTRATION PLANT

Raw water from the low-lift pumping plant flows by gravity under the turbine house to the mixing chamber, where a small amount of chlorine is added. The water prior to reaching the mixing chamber is dosed with a solution of alum and ammonium sulphate and, as this solution is added before reaching the low-lift plant pumps, these aid in the mixing process. The alum serves to coagulate and entrain the suspended matter in the water. The chlorine and ammonium sulphate form chloramines which serve to sterilize the incoming water, thereby placing less bacterial load on the plant. From the mixing chamber, the water passes to the sedimentation basin, where its detention is two hours at the normal rate of operation.

After the sedimentation the water flows to the filters where the material which was too fine to settle is removed. Sand filters which are constructed for backwashing, filter at the rate of 0.3 ft per minute. After filtration, another small quantity of chlorine is injected as the water is conveyed to storage reservoirs or to the high-lift pumping plant.

The filtration plant will ultimately consist of 68 filters of 272 mgd total capacity. Each filter has an area of 0.025 acres and is of the rapid sand type designed for an output of 4 mgd, or 160 mgd per acre per day. The filter medium consists of 20 inches of filter sand on top of 18 inches of gravel varying in size from coarse to fine.

The average amount of chemicals used for dosing is as follows: alum 100 lb per mg, ammonium 2 lb per mg, prechlorine 1.5 lb per mg, postchlorine 1.0 lb per mg.

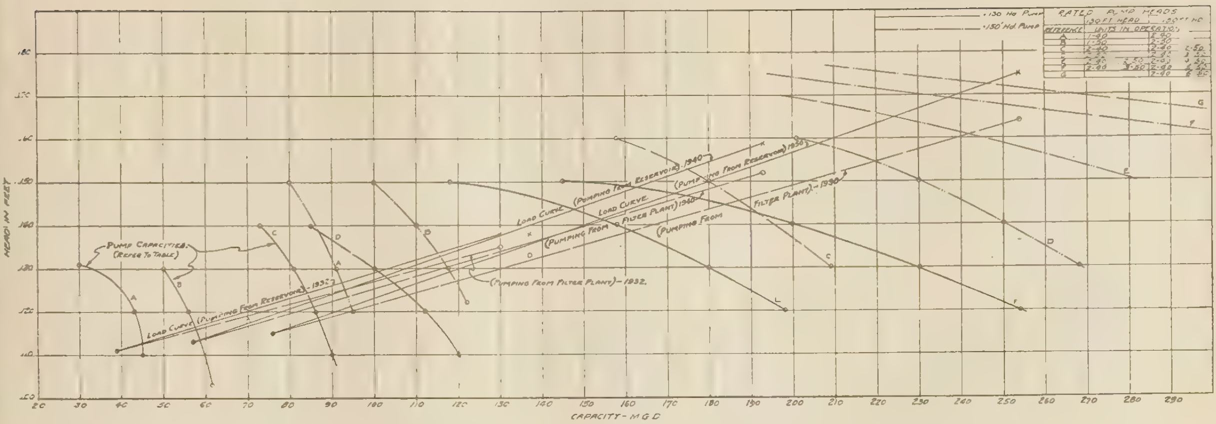


Fig. 5 Characteristic Curves for Centrifugal-Pump Output

Eventually there will be three 20-million-gallon filtered-water reservoirs amounting to 22 per cent of the maximum capacity of the filter plant. Two reservoirs of concrete construction about 20 ft deep and with an area of 3.3 acres are now in service. The mixing chamber, sedimentation basins, filters, chemical house, laboratory, and reservoirs are all grouped as a part of the filtration system.

High-Lift Pumping Plant

The high-lift or filtered-water pumping plant taking water from the filter plant or underground-reservoir storage, delivers it to the city-mains distribution system. Because of the extensive area covered by the system, it is divided into four independent zones, two high-pressure, one intermediate-pressure, and one low-pressure. Springwells Station supplies one of the high-pressure zones and, in parallel with Water Works Park Station, the intermediate-pressure zone. The low-pressure zone is served solely by Water Works Park Station. The high-lift plant accordingly operates in two sections at different pressures.

There are 16 pumps, placed in pairs in 8 pump pits, each about 18 ft deep. The present sizes are 17, 30, 40, and 50 mgd each. Ultimately the 17-mgd units will be replaced by 40- and 50-mgd units making the total installed capacity 680 mgd.

Driving the pumps are four slip-ring and twelve synchronous motors of 700 to 1725 hp. The heads pumped against are 140 and 200 ft, respectively, for the intermediate- and high-pressure zones. Each pump is connected to a double main, located in the pipe vault, through an automatic check valve and hydraulic gate valves. The six distribution mains leading from the pumping plant to the street mains are constructed of 72-in. steel pipe. All pumps are controlled from the main switchboard. Fig. 4 shows a cross section through the high-lift pumping plant, with the arrangement of the pumps and piping.

The centrifugal pumps have a steep capacity-head characteristic, but even so it was necessary to install 680 mgd capacity in order to provide for a maximum hour rate of 400 mgd, with 70 mgd in pumps in reserve capacity. Hence, it was necessary to install a rated pump capacity of over 50 per cent greater than the maximum demand. A typical characteristic-curve study for the selection of pumps to match the city-water demand is shown in Fig. 5. This figure shows the relation of the load curve, which rises as the load increases with respect to the capacity-head curve of the centrifugal pump, where decreasing capacity accompanies increased head.

Check and Gate Valves. Other features of the pumping plant which merit a short description are the check and gate valves. One of the most important functions in a pumping plant is that performed by the check valve in the discharge line of pumps. Water check valves must close quickly, without water-hammer effect, and should also be equipped to permit throttling of the flow. Eighteen automatic-type water check valves in sizes of 16 in. to 36 in. are installed. All main gate valves on the pumps are of the hydraulically operated solid-wedge disk type. The water pressure for operating the gate and check valves is 100 lb per sq in. supplied by booster pumps, storage tanks, and piping system.

2 ENGINEERING STUDIES OF PUMP DRIVES

The Springwells Station when first proposed, presented several design complications as the result of: (*a*) the necessarily depressed hydraulic grade line at the site attendant upon a long river-water tunnel, (*b*) the location with respect to the city-mains distribution system and its fluctuating water flow, and (*c*) the consideration of economy of operation and similar factors. The first problem was met as has been described by the construction of a deep-well low-lift pump plant. The second and third difficulties happily were met simultaneously by the use of motor-driven centrifugal pumps throughout the station with combinations of constant-speed and adjustable-speed motors of various sizes to accommodate efficiently the load variations. The considerations governing the selection of pumps are reviewed under the title "Relative Pumping-Equipment Costs." The sources of power supply, and electrical generating plant on the site, and partial stand-by service, are described in other sections.

Relative Pumping-Equipment Costs

Engineering studies were made on the relative construction and operating costs of the plant. At the outset, the following types of drive for centrifugal pumps were considered:

1 Steam-turbine drive through helical reduction gears
2 Variable-speed electric drive with
   (*a*) A combination of constant- and adjustable-speed motors
   (*b*) Slip-ring type motors.
3 Constant-speed electric drive, with
   (*a*) Synchronous motors
   (*b*) Squirrel-cage motors.

Preliminary studies based on available cost data and load-duration data led to the following conclusions: (*a*) The total investment required for each type of motor drive is less than for turbine drive; (*b*) the annual costs for fuel, maintenance, and labor is less for motor drive than for steam-turbine drive; (*c*) the reliability afforded by motor drive is at least equal to that of turbine drive. This particular conclusion was premised

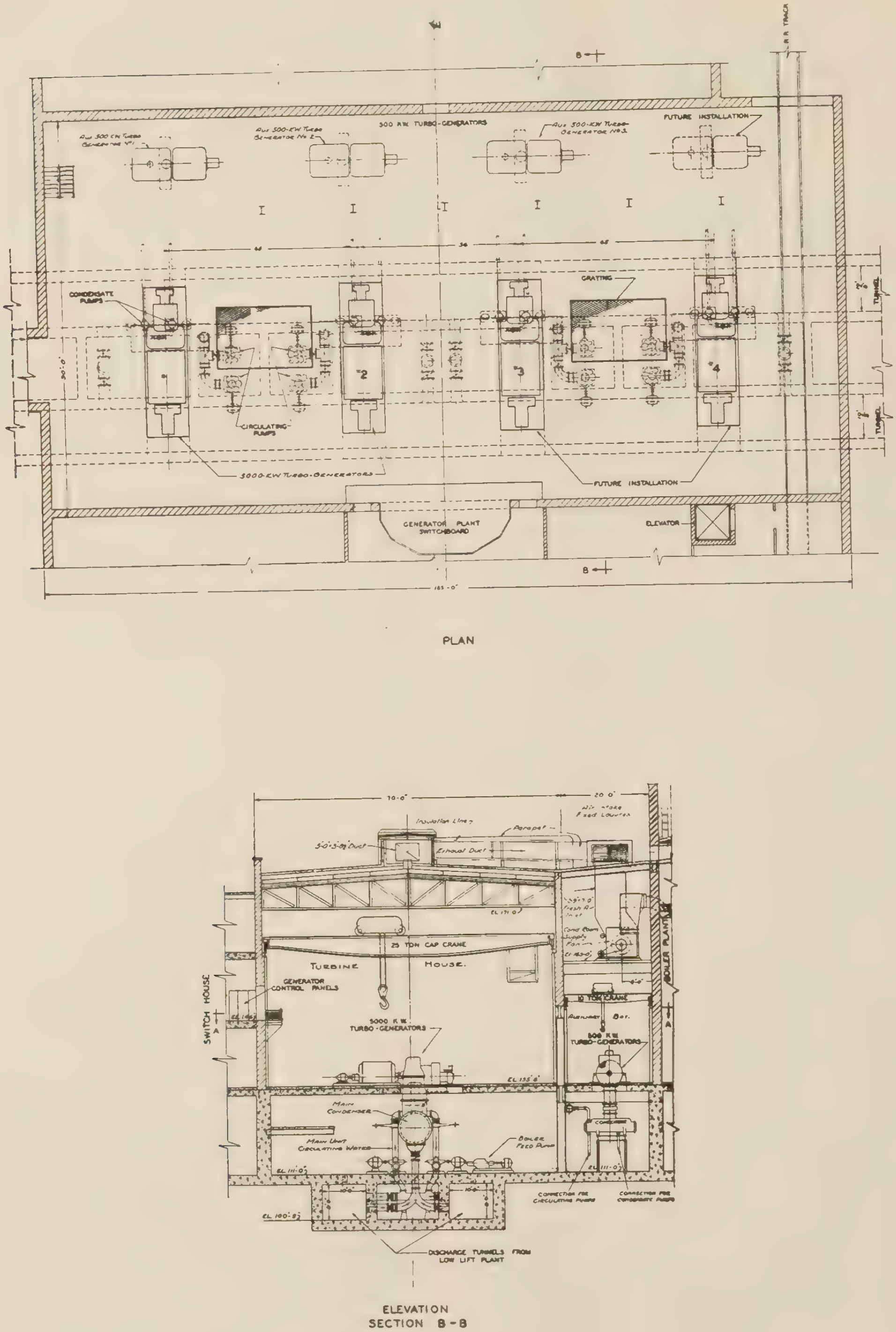


Fig. 6 Plan and Elevation of the Turbine House, Showing Main and Auxiliary Turbogenerators, Condensers, and Piping

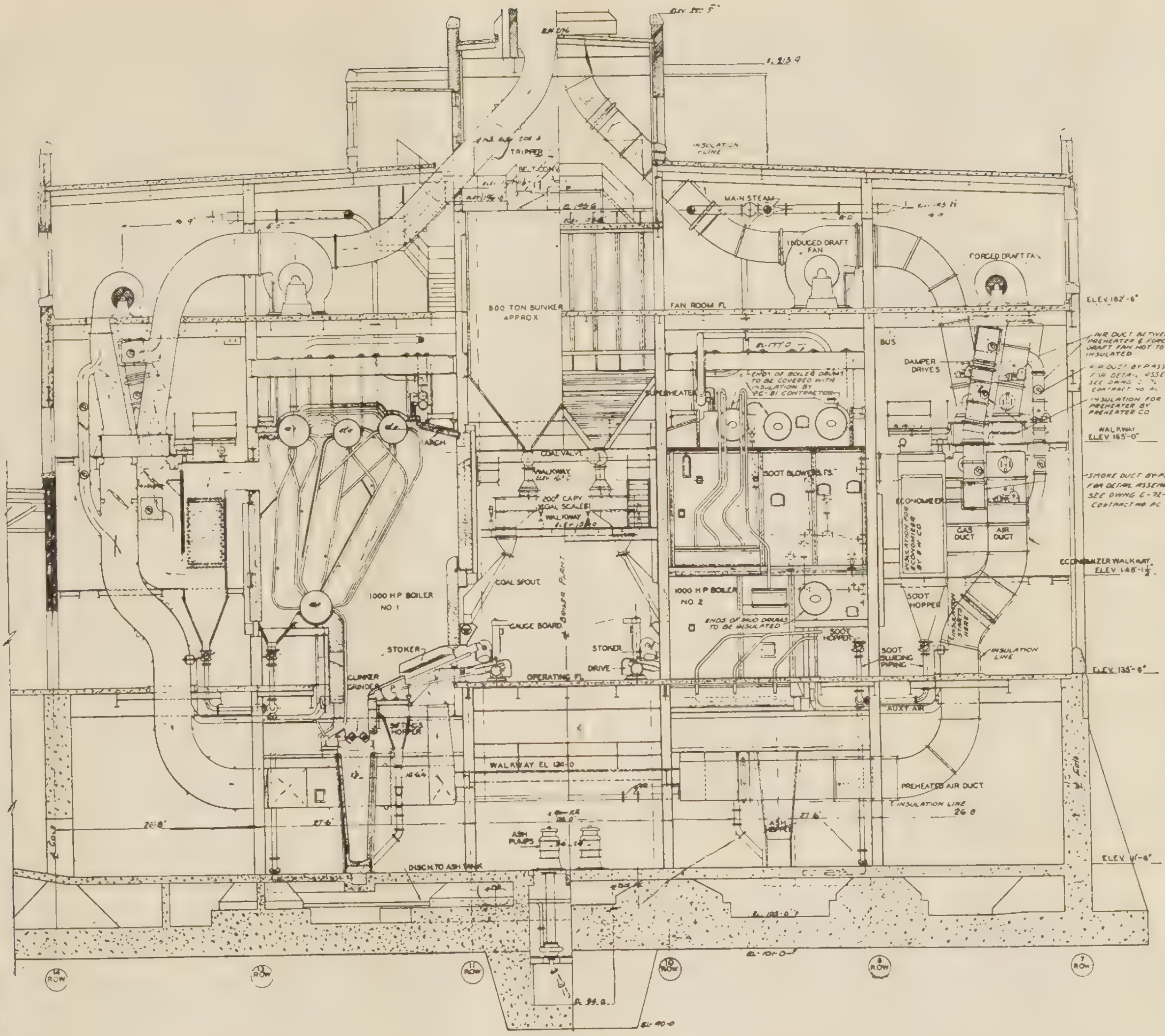


Fig. 7 Cross Section of Boilerhouse, Showing Design of Major Units of Steam-Generating Equipment

on the installation on the site, of turbogenerators having a capacity equal to the maximum hour capacity and a stand-by transformer installation equal to the capacity of one turbogenerator, to permit shutting down for overhaul; (*d*) capacity and head regulation adequate for conditions of minimum, average, and maximum demand can be obtained by providing one or two variable-speed slip-ring motors in each service.

The final engineering study was reduced to four schemes, namely:

1 Alternating-current motor drive for all main pumping units, embodying a combination of constant-speed, synchronous, and variable-speed slip-ring motors.

2 Steam-turbine drive for all high-lift pumps and d-c motor drive for all low-lift pumps.

3 Steam-turbine drive throughout.

4 Steam-turbine drive in the high-lift plant and water-turbine drive in the low-lift plant.

The comparative estimates are summarized in Table 1. The figures, although comparable, are not complete as they do not include those costs common to all schemes.

TABLE 1 COMPARATIVE COST ESTIMATES FOR PUMPING STATIONS AND EQUIPMENT OF ITEMS NOT COMMON TO ALL SCHEMES

Plan	Construction cost	Annual operating cost
Alternating-current motors throughout	$2,316,560	$588,160
Steam turbines in high lift and d-c motors in low lift	2,537,050	638,470
Steam turbines throughout	2,319,050	619,630
Steam turbines in high lift and water turbines in low lift	2,559,360	662,110

On the basis, therefore, of a lower cost in the plant as a whole, and of greater reliability in the low-lift plant, motor equipment throughout, with an adjoining steam-electric generating plant, was adopted by the Board of Water Commissioners (6, 7).

Precedents for Pumping Equipment

Prior to 1923, all water pumping in Detroit had been done with plunger pumps, driven by reciprocating steam engines. The original installation at Water Works Park, consisting of one compound pump with a capacity of 24 mgd, was put into service in 1877. Then, during the following 46 years, 10 triple-expansion and two compound engines, with capacities of 25 to 37 mgd

were installed. In the year 1924 there was installed in this station a total capacity of 378 mgd in steam pumping engines.

It is of interest to note that, although the policy of the Water Department until 1924 was to distribute water with triple-expansion engines, since that time all new units, including all of the new Springwells plant, have been motor-driven centrifugal pumps.

3 POWER PLANT

The necessity for insuring absolute continuity of service prompted the choice of an electric power-generating plant on the Springwells site rather than dependence wholly on transmission lines from outside supply, even if available from two independent sources. Limited throw-over service has been provided for reserve capacity, however, to the extent of one main unit. The power-plant design was based on generating 95 per cent of the power requirement and purchasing the remainder from a central-station source. It was estimated that water pumpage would require 4000 kw per 100 mgd or about 96,000 kwhr daily.

The initial installation consists of two 5000-kw main and three 500-kw auxiliary turbogenerators with a 5000-kw stand-by transformer bank connected to the Public Lighting Commission's system to provide an emergency supply from an outside source. This capacity is sufficient for a maximum hourly pumping rate corresponding to 275 mgd or 11,400,000 gal of water per hr. The steam-generating equipment includes two boiler units each with a maximum output of 90,000 lb of steam per hr.

The ultimate installation will consist of four 5000-kw main units, four 500-kw auxiliary turbogenerators, and four 90,000-lb per hr boilers. The stand-by connection of 5000 kw will, of course, be retained. The ultimate plant is designed to match the maximum hourly pumping rate corresponding to 550 mgd or 22,800,000 gal of water per hr. A cross-sectional elevation of the powerhouse is shown in Figs. 6 and 7.

Turbogenerators

The main steam turbines are 15-stage, 3600-rpm machines, designed for operation at 350 lb gage steam pressure, 700 F temperature, and condensing operation at a back pressure of $1^1/_2$ in. mercury. The generators rated at 5000 kw, at 80 per cent power factor, are 4600-volt, 3-phase, 60-cycle. The turbines are equipped with bleed points at the ninth and twelfth stages for extraction-steam feedwater heating.

The auxiliary turbogenerators are 6-stage, 500-kw at 80 percent power factor, 460-volt, 3-phase machines, with condensers. The turbines are of special bleeder type to supply building-heating requirements.

Condensing Water

The condensing water for the condensers is taken from one of the two raw-water tunnels passing through the condenser room as shown in Fig. 2. The water is drawn through the main-unit 10,000-sq ft surface condensers by means of two 4000-gpm, $13^1/_2$-ft head, d-c-motor-driven centrifugal pumps. Because of conditions requiring the condensers to be below water level, the pumps need to overcome friction and velocity-change losses only. The 800-sq ft condensers for the auxiliary turbines are supplied from an auxiliary tunnel connected to the main raw-water tunnels. Each machine has one condensing-water pump, driven by a d-c motor. Since the amount of condensing water is small compared with the quantity of raw water being pumped, the increase in raw-water temperature is negligible.

Power-Plant Auxiliaries

After an extended study of the various types and methods of operating power-plant auxiliaries, it was decided to provide the power plant with 240-volt, d-c motor-driven auxiliaries, with adjustable speed control for each motor using a heavy-duty drum-type controller, mounted in a steel cubicle with a carbon circuit breaker, ammeter, and related equipment. Power is supplied through an open-type ring bus made up of three $4 \times {}^1/_4$-in. copper bars making a complete circuit of the turbine room and boilerhouse. The 240-volt direct current is supplied by three 400-kw motor-generator sets, operated on 460-volt, 3-phase power from the 500-kw turbogenerators.

The power-plant auxiliaries are entirely separated from the auxiliary-power equipment of the pumping and filtration plants, where 440-volt, 3-phase a-c motor-driven auxiliaries are used.

Stand-by Power Supply

The power plant was designed to have a central-station feeder with a capacity equal to one main turbogenerator to meet emergency requirements, such as loss of one of the generators during peak loads. Hence, it was not necessary to provide reserve capacity in main turbogenerators and boilers.

The central-station feeder is a 24,000-volt line from the Public Lighting Commission's system, which has an 80,000-kw steam-generating plant about five miles from the Springwells Station. This feeder is connected to a 5000-kw, 80 per cent power factor, 24,000/4600-volt power transformer. The service is used continuously at a very low load, about 100 kw, and is ready for stand-by service up to a demand of 5000 kw. The Springwells generators are operated in synchronism with the P.L.C. power system.

Electrical System

The electric-power system was designed for 4600-volt, 60-cycle, 3-phase alternating current for the main units; 460-volt, 60-cycle 3-phase power for the auxiliary units; 240-volt d-c power for the power-plant auxiliaries; 220-volt d-c power for the exciters of the synchronous motors of the main pumps; 125-volt power from storage batteries for operation of oil circuit breakers and emergency lighting system; 110/220-volt, 3-wire, a-c lighting system and 18-volt power from storage battery for operation of the switchboard signal system.

The 4600-volt switchgear is of the metal-clad oil-circuit-breaker vertical-lift, heavy-duty type. The bus is arranged in five parts, one for each main turbogenerator plus a synchronizing bus that is connected to the generator bus sections through bustie reactors.

The main switchgear and bus system required much study from the standpoint of (*a*) the size and current-interrupting capacity of the oil circuit breakers, (*b*) the surges caused by starting motors on large centrifugal pumps, (*c*) the central-station feeder, and (*d*) the operating problems with 5000-kw turbogenerators in synchronism with a central-station power system.

The 460-volt switchgear is of the oil-circuit-breaker, metal-cubicle type. The bus is in duplicate so that each feeder may be supplied by either bus.

There are three separate storage batteries, each complete with its battery-charging motor-generator sets. There are two 60-cell storage batteries for 125-volt service, one for operating solenoids on the oil circuit breakers and the other for the emergency lighting service throughout the various buildings. The third storage battery is of the 8-cell, 18-volt type, for operation of signal and instrument lights on the switchboards in the pumping and power plants.

Steam Generation

Each steam-generating unit includes a boiler, and underfeed stoker, superheater, air heater, economizer, and a forced-draft

and an induced-draft fan. The 4-drum bent-tube boiler is designed for 380-lb pressure and a normal output of 70,000 lb of steam per hr. Provision is made for a maximum evaporation up to 90,000 lb per hr. The side and bridge walls of the 4125-cu ft combustion chamber are lined with $3^1/_4$-in. OD No. 7 Bwg plain water-cooled tubes. The total radiant and convection heating surface amounts to 10,898 sq ft per boiler.

A convection superheater of 1740 sq ft is located in the first gas pass to receive a portion of radiant heat at low rating and accordingly to minimize the range of superheated-steam temperature variation. At the maximum rating the guaranteed steam temperature is 715 F.

The economizer surface amounting to 2673 sq ft per unit is installed. It consists of 2-in. OD plain tubes stacked 22 tubes high and 16 tubes wide, joined by wrought-steel return bends.

The air heater which is of the mechanical regenerative rotating type has an active heating surface of approximately 9500 sq ft and supplies air to the fuel bed at temperatures up to 300 F.

The underfeed stoker for each boiler unit has 8 retorts each with 31 standard-thickness tuyères and a 4-row undulating-link extension grate. The total projected area of each stoker is 195 sq ft. Each stoker is guaranteed to burn 8900 lb per hr of 13,500-Btu coal and 11,000 lb per hr of 12,000-Btu coal. The stoker is driven through a crankshaft by a d-c motor with a drum-type manually operated controller. The clinker grinder is separately operated by a manually controlled d-c motor.

A steam-generating unit includes one induced- and one forced-draft fan separately driven by adjustable-speed d-c motors. The fans, located on the top floor of the boilerhouse, are designed for starting and stopping at that point. Speed is remotely controlled from the boiler-operating board located on the main floor of the boiler room near the stoker. The forced-draft fan is designed for a maximum capacity of 45,000 cu ft per min of air at 70 F, against a static pressure of 13.5 in. of water. The induced-draft fan is rated at a maximum capacity of 75,000 cu ft per min of flue gas at 300 F, against a static-pressure differential of 11.0 in. of water.

In front of each boiler is a control panel on which are mounted the operating instruments such as steam-flow air-flow meter, draft gages, CO_2 meter, pressure gages, temperature instruments, and controls for forced- and induced-draft fans, stokers, dampers, and related items.

Piping System. The superheated-steam piping system is arranged as a loop header at the top floor of the boilerhouse with two 8-in. supply feeders leading to the basement of the turbine house where there is another 10-in. pipe loop-header system which connects with the feeders for each main and auxiliary turbine. The piping is laid out and all necessary sectionalizing valves are installed so that additional changes will not be necessary when future turbines and boilers are installed.

There are also two 4-in. saturated-steam headers connected to each boiler and leading to duplicate pressure-reducing stations, where steam is reduced from 380 to 200 lb per sq in. Duplicate 200-lb pressure lines convey steam to feeder lines for auxiliaries such as soot blowers and air ejectors. The 200-lb pressure line is connected to a second reducing station to provide a 3 to 8-lb emergency steam supply for building heating.

Feedwater Cycle. Condensate from the auxiliary units and building-heating returns are injected into the main-unit condensers for deaeration before returning to the feedwater system. Duplicate hotwell pumps of 250 gpm and 200-ft head driven by d-c motors, discharge condensate through two stages of feedwater heating to the suction of the boiler feed pump at approximately 40 lb pressure. Make-up water amounting to $1^1/_2$ per cent of the total boiler feed is evaporated in an evaporator that is supplied with steam from the ninth-stage extraction line of each main turbine.

There are two feedwater-storage tanks of the open type filled with distilled water to meet emergencies and fluctuations in condensate demand attendant upon load changes. Storage-tank water is discharged to the main condensers to be deaerated before entering the boiler feed system.

Condensate in the main condenser is maintained at a predetermined level by two float valves, one of which is set higher than the other. The hotwell-pump supply of condensate to match the demand for boiler feed is thus insured. Any excess condensate is pumped through one float-operated valve to the storage tanks. In case of a deficiency, water is fed back to the main condenser from the storage tanks through the other float-operated valve.

The design provides for an ultimate installation of five boiler feed pumps, two to be steam-turbine driven and three d-c-motor driven. For the present installation three six-stage centrifugal pumps have been provided, each of 300-gal-per-min capacity at 1050 ft head, to deliver feedwater at a temperature of 275 F to the economizers, and thence into the boilers. One of these pumps is driven by a steam turbine and two by d-c motors.

Building Heating. The heating system for the buildings, designed for a steam demand in zero weather of 25,000 lb per hr, normally is supplied by bleeding steam from the auxiliary turbines at gage pressures of 2 to 5 lb. The heating-system condensate is returned under vacuum to the main-turbine condensers for deaeration. Before reaching the condenser, the heating returns pass through a heat exchanger to transfer some heat to the feedwater.

Coal Handling. An outside coal-storage capacity of 18,000 tons is provided to which coal is brought by means of railroad cars or motor trucks. Coal is unloaded directly into a track hopper and conveyed to coal bunkers or placed in the coal-storage pit. Handling from the outside storage pit to a reclaiming hopper is by means of a motor-operated 2-cu yd dragline scraper capable of handling 75 tons of coal per hr. From the reclaiming hopper, the coal is carried on an apron conveyor conveying it to a crusher in which the lumps up to 24 in. in size are crushed to a final product not exceeding $^3/_4$ in. in size. From the crusher the coal is raised by a bucket elevator to a 100-ton per hr belt conveyor from which it can be distributed to the bunkers or by-passed to a chute for outside coal storage.

Ash Handling. Refuse from the boilers, after passing through the clinker grinders, drops into an ash hopper directly underneath. From the ash hopper cinders are handled through sluiceways into a water-filled ash-pump pit from which the refuse mixed with water is pumped to an overhead ash-storage tank by means of two centrifugal pumps. Cinders are removed from the ash-storage tank by dumping into motor trucks.

Summary of Power-Plant Features

In concluding this section on the power-plant design, there are certain unusual features that should be emphasized. For example, the combination pumping and power plants were designed for a four-step power-conversion plant (coal, steam, electricity, mechanical power), whereas nearly all other steam-operated water-works plants are of the three-step power plan (coal, steam, mechanical work) (8). The use of reasonably high steam pressures and temperatures (380 lb, 715 F) was also of marked interest. There were many features that received special study, prior to making decisions, such as type and size of electrical switchgear, size of turbines and boiler units, type of stokers, building heating, feedwater cycle, and coal and ash-handling systems.

4 EXPECTED PERFORMANCE GUARANTEES, AND ACCEPTANCE TESTS

In preparing plans, specifications, and contracts for securing plant equipment, operating schedules were prepared and from these, estimates were made on expected performance of equipment. Bids were obtained based on guaranteed results with penalty and bonus clauses in the contract. This feature is an important phase of purchasing major equipment for a municipal project in that the city charter of Detroit requires that contracts be awarded to the lowest responsible bidder. The bids were evaluated, based on contract cost, plus the power-operating costs over a 20-year period, with such items as interest, cost of power, hours of operation, and similar items taken into account. The contracts were awarded on the basis of the lowest evaluated bid, where the bidder complied with all requirements of the specifications, with the understanding that field tests were to be performed and a bonus or penalty applied to the contract, depending on whether the field tests showed better or poorer performances than those guaranteed by the bidder.

The contracts for the major pumping equipment required that the contractor construct and test to the satisfaction of the water department, a model pump or pumps. These models were used and from the test results obtained on them, there was calculated the expected performance that would apply to the full-sized pumps. The latter were constructed in direct ratio to the size of the model pump as to design of all parts of the pumps. The results obtained through designing from model-pump tests have been most satisfactory. One of the reasons for having model pumps constructed is that pump manufacturers are unable to test large pumps in their shops. Further, model pumps offer the manufacturers economical means of altering pump designs which would not otherwise be practicable in constructing large pumps. By making proper allowances for ratio factors, the model-pump test is considered equal to tests on full-sized pumps.

Since design and cost data are technically open to public inspection, contract prices, bonuses, and penalties are given in this paper. Reviews are outlined on the acceptance tests on (*a*) the hydraulic pumps in the low- and high-lift pumping plants, (*b*) the turbogenerators, and (*c*) the steam-generating equipment.

Acceptance Tests of Hydraulic Pumps

Field acceptance tests were made after the equipment had been installed and operated.

The field test methods and results are described in the following sections.

Pump-Test Methods. Heads were measured by means of mercury manometers and piezometer on the suction and discharge flanges of the pumps. Capacities were measured by means of a manometer connected to large venturi tubes. The specific gravity of the manometer fluids varied from about 1.25 to 2.8 depending upon the size of the venturi tube and the flow to be measured. Power input to the motors was measured with an indicating polyphase wattmeter and checked with a rotating standard.

The test procedure followed as nearly as possible the A.S.M.E. Power Test Code. Each pump in the low-lift and high-lift plants was tested over the operating range of heads and a separate test curve was plotted. In general, the duration of each test was for a period of twenty minutes with sufficient time interval at each test load to allow stabilization of the new load. Changes of load were accomplished by throttling the discharge or check valves of the pumps.

The determination of heads on the low-lift pumps was especially difficult because of the low head range of these pumps (40 to 70 ft total dynamic head). A pressure-equalizing ring encircling the suction and discharge flange and connected at the quarter points of the pipe was installed on all pumps, and the head-measuring manometers were connected to the pressure rings.

A manometer or U tube was used to measure the discharge heads on the high-lift pumps. The open end extended about 18 ft from the floor of the pump pit.

Discussion of Pump-Test Results. When the preliminary tests on the low-lift pumps indicated that the performance of several pumps was below guaranteed conditions, the contractor was allowed to replace three impellers and to work on other impellers in order to increase efficiencies and more nearly meet guaranteed capacities. A summary of the average overall weighted test efficiencies with bonus and penalty amounts appears in Table 2.

The field tests on the pumps showed that they varied from the predicted results, obtained from the tests on the model pumps, from 3 per cent below to 1 per cent above the overall weighted efficiencies, while the field-test efficiencies varied from 0.75 per cent below to $3^1/_2$ per cent above the guaranteed efficiencies. The bonus anticipated by the pump contractor was less than indicated from model-pump-test results. Nearly all the

TABLE 2 SUMMARY OF ACCEPTANCE-TEST RESULTS LOW- AND HIGH-LIFT PUMPS AVERAGE OVERALL WEIGHTED EFFICIENCIES—PER CENT

Pump number	Guaranteed	Predicted from model tests	Field test	Total excess or deficiency for each class of pumps, per cent	Bonus or penalty, rate per cent	Bonus	Penalty
Low-lift pumps							
1 and 2 30 mgd at 50 ft	74.662	77.585	73.886	−1.552	$1,000.00	......	$1,552.00
3, 4, and 5 60 mgd at 50 ft	79.57	82.045	79.503	−0.200	2,000.00	......	400.00
6, 7, and 8 60 mgd at 60 ft	80.79	82.51	81.022	+0.696	2,000.00	$1,392.00	.....
					Totals.......	$1,392.00	$1,952.00
					Net penalty		560.00
High-lift pumps							
13 and 19 30 mgd at 200 ft	79.592	81.63	81.482	+3.780	$1,300.00	$4,914.00	.....
14 and 20 40 mgd at 130 ft	80.558	82.59	81.0595	+1.003	1,100.00	1,103.30	.....
11, 15, 17, and 21 40 mgd at 200 ft	84.176	86.35	84.817	+2.564	1,700.00	4,358.80	.....
16 and 18 50 mgd at 130 ft	84.255	84.50	83.906	−0.698	1,400.00	......	977.20
12 and 22 50 mgd at 150 ft	82.521	85.27	86.132	+7.222	1,600.00	11,555.20	.....
					Totals.......	$21,931.30	$977.20
					Net bonus...	20,954.10	

pumps were overcapacity, which was remedied on some of the pumps.

The idea of pump testing in the field, its advantages and disadvantages, has been under active discussion for some time. It has been borne out in this case that it is to the purchasers' advantage, especially where bonus and penalty contracts apply, to have acceptance tests made in the field, but it is also to the mutual advantage of the purchaser and manufacturer to have shop tests made on pumps prior to shipment, either model-pump tests or tests on the full-sized pumps.

Turbogenerator Acceptance Tests

The contracts for turbogenerators included a bonus and penalty clause establishing a value of $20 per lb of weighted steam flow per hr. The manufacturer guaranteed the turbogenerators at the various loads set up in the contract (a definite weight factor to be used in averaging was established for each load) for both extracting and condensing operation, although the contract specified that field tests were to be made with full condensing operation.

Before testing operations began the units had operated longer than had been anticipated and therefore each machine was opened and cleaned thoroughly in preparation for test. In so far as possible, the test methods used conformed to the A.S.M.E. Power Test Code. Condensate was weighed with 10,000-lb test weigh scales. Initial steam temperature was measured with mercury-in-glass thermometers calibrated for full immersion and calibrated thermocouples. Initial steam pressure was measured with dead-weight gages and checked by Bourdon pressure gages, graduated in 2-lb divisions. The electric-power output of the generator was measured by means of two single-phase indicating wattmeters. Condenser leakage was measured with a dionic water tester. Corrections were applied to the field results for condenser leakage, throttle steam pressure, temperature, and back pressure.

A back pressure of $1^1/_2$ in. abs was maintained constant by a bleeder valve connected to the condenser and a direct-reading back-pressure gage. Back pressure was measured by difference between a mercurial barometer and two specially built mercury-column vacuum gages. Each of these instruments could be read to 0.01 in. of mercury. The tubes of the vacuum gages were of large bore to eliminate the need of correction for capillarity.

All instruments were calibrated before and after the tests.

In order to indicate clearly the method of evaluating the weighted steam flow and the application of the bonus and penalty system, Table 3 is included to show the guarantee on the 5000-kw turbogenerators.

TABLE 3 SUMMARY OF GUARANTEED WEIGHTED STEAM FLOW FOR ONE 5000-KW TURBOGENERATOR

Load kw	Power factor	Total steam flow, lb hr	Weight factor	Weighted steam flow, lb hr	Steam rate, lb-kwhr
2500	0.8	26,900	0.05	1345.0	10.76
3000	0.8	31,410	0.05	1570.5	10.47
3500	0.8	35,945	0.10	3594.5	10.27
4000	0.8	40,560	0.20	8112.0	10.14
4500	0.8	45,135	0.20	9027.0	10.03
5000	0.8	49,800	0.25	12450.0	9.96
5500	0.88	54,725	0.10	5472.5	9.95
6250	1.00	62,500	0.05	3125.0	10.0
Guaranteed weighted steam flow				44,696.5	

The values which are given in Table 3 are based on straight condensing operation with steam at a pressure of 350 lb per sq in. gage and with a temperature of 700 F at the turbine throttle and against a back pressure of $1^1/_2$ in. mercury.

TABLE 4 COMPARISON OF GUARANTEED AND TEST PERFORMANCE 5000-KW AND 500-KW TURBOGENERATORS

	5000-Kw units		500-Kw units	
Load range, kw	2500 to 6250		125 to 625	
Power-factor range	0.8 to 1.00		0.8 to 1.00	
	Guarantee	Test	Guarantee	Test
Steam-rate range, lb per kwhr	9.95–10.76	9.77–10.96	12.80–17.60	13.32–18.13[a]
Weighted steam flow, lb per hr	44,696.5	No. 1—44,928 No. 2—44,070	5350.25	No. 1—5531[a] No. 2—5632
Net bonus	..	$7885	..	

[a] Figures given for two 500-kw turbines only. Test on third machine not completed.

Results of Turbogenerator Tests

The turbogenerators were delivered and erected in the years 1931 and 1932. However, due to the effects of the depression they were not operated until February, 1935, and field tests were not begun until October 30, 1935, although during the time the turbines were idle the internal parts were slushed with a protective coating, and the buildings were heated in winter.

The A.S.M.E. Power Test Code states that "the turbine must be in commercial operating condition." Since this applies to cleanliness, it is thought it should be more specific as this can be a serious point of contention between the owner and the manufacturer. Inasmuch as dirty blading can affect the performance of a turbine considerably, the owner has a legitimate right to insist that the turbine be tested in a normally clean condition so that test results will conform more closely to operating conditions. The manufacturer will probably insist that the turbine be tested in a factory-clean condition, which is not possible to attain in the field, even after a few days' operation.

The field-test results on the turbines are given in Table 4.

Boiler Acceptance Tests

The specifications for boiler-plant equipment stated that acceptance tests were to be made on all equipment by the Department of Water Supply in the presence of manufacturers' representatives. Due to a variety of conditions, the boilers were in operation approximately seventeen months before acceptance tests were conducted. In so far as practicable, the test methods conformed with the A.S.M.E. Boiler Test Code. The most unusual departure from the A.S.M.E. Code concerned the determination of feedwater quantity. The plant is not equipped to weigh feedwater although test weigh scales are provided for the weighing of condensate for turbine testing. A mechanical-type flow meter connected to a six-inch venturi tube in the boiler feed line was used to measure the feedwater. This meter was calibrated by means of the test weigh scales before and after the tests. Coal was weighed on automatic coal scales, which were calibrated with test weights. The various gas and air temperatures were measured with iron-constantan thermocouples connected through a selector switch to a potentiometer pyrometer. The temperature of superheated steam was measured by both a thermocouple and a mercury-in-glass thermometer. Refuse was not weighed but samples were collected and analyzed for contained combustible matter. The quantity of refuse was estimated by the A.S.M.E. formula. Flue-gas samples were drawn from three points in the duct at each sampling point and led to a combination mixing and bubbling jar by means of an air-operated aspirator. Adjustments in gas flow in the three sampling lines were controlled by pinch cocks to divide the flow equally. Orsats were of both the metal and glass types. Fuel was sampled at the stoker hopper and analyzed several times during each test for moisture content. The distillation method was used for moisture determination. After each test the total collected coal sample was reduced and sent to the laboratory for analysis.

The coal used for boiler tests was from the Pittsburgh seam in western Pennsylvania. This is a low-sulphur semicaking type coal. The average proximate analysis of the coal used for all boiler tests was as follows:

Moisture	3.03 per cent (as fired)
Volatile matter	32.38 per cent (dry basis)
Fixed carbon	60.88 per cent (dry basis)
Ash	6.74 per cent (dry basis)

Heating value, Btu per lb (dry basis)—14,040.

Results of Tests on Steam-Generating Equipment

The results of the boiler tests conformed satisfactorily with the guaranteed values. It is believed that slightly better efficiencies could be obtained under ideal conditions of operation; the values of CO_2 in the flue gas during boiler tests were slightly lower than is ordinarily obtained in normal operation. This was mostly due to the slightly inferior burning characteristics of the coal used for boiler tests. The losses unaccounted for varied from 3.19 to 7.54 per cent. The higher value corresponds to the low boiler rating (less than 30,000 lb of steam per hr) and an intermediate value of 3.29 per cent corresponds to load of 56,000 lb of steam per hr.

The guaranteed and test results of the steam-generating equipment are given in Table 5.

The estimated design heat balance, based on average winter-season load for the year 1950, indicated a steam-boiler generating unit overall efficiency of approximately 83 per cent and a resulting annual heat rate of the power plant in "coal to switchboard," of approximately 18,100 Btu per net kwhr.

The average annual expected heat-rate results of the ultimate plant are as follows:

Coal, lb per kwhr (13,500 Btu per lb)	1.34
Thermal efficiency of the power plant, per cent	18.85
Thermal efficiency of the pumping plant, per cent	14.5
Annual heat rate of power plant, Btu per kwhr	18,100
Electric power, kwhr per whphr	1.01
Coal required to pump 1,000,000 gallons of water 100 feet high, lb	570

5 OPERATION AND COMPARISON OF OPERATING RESULTS WITH ACCEPTANCE TESTS

Construction work for the entire station was practically complete except for the power plant at the end of 1932. Although the pumping plants and the filtration plant were placed on part-time operation in 1931, the city's financial difficulties together with the lower load on the system because of the depression delayed the final completion of construction and arrangements for placing the station on a twenty-four hour per day basis until 1935.

During the period of inactivity, or rather, throughout 1933 and 1934, a small group of employees now in the operating division was engaged in making trial operations of all equipment in the pumping plants and in conducting and making up reports on acceptance tests of the equipment. This work included tests of each individual pumping unit in the low- and high-lift pumping plants.

Pumping Plants

The average daily pumpage by the high-lift pumping plant during the fiscal year ending June 30, 1936, was 112.3 million

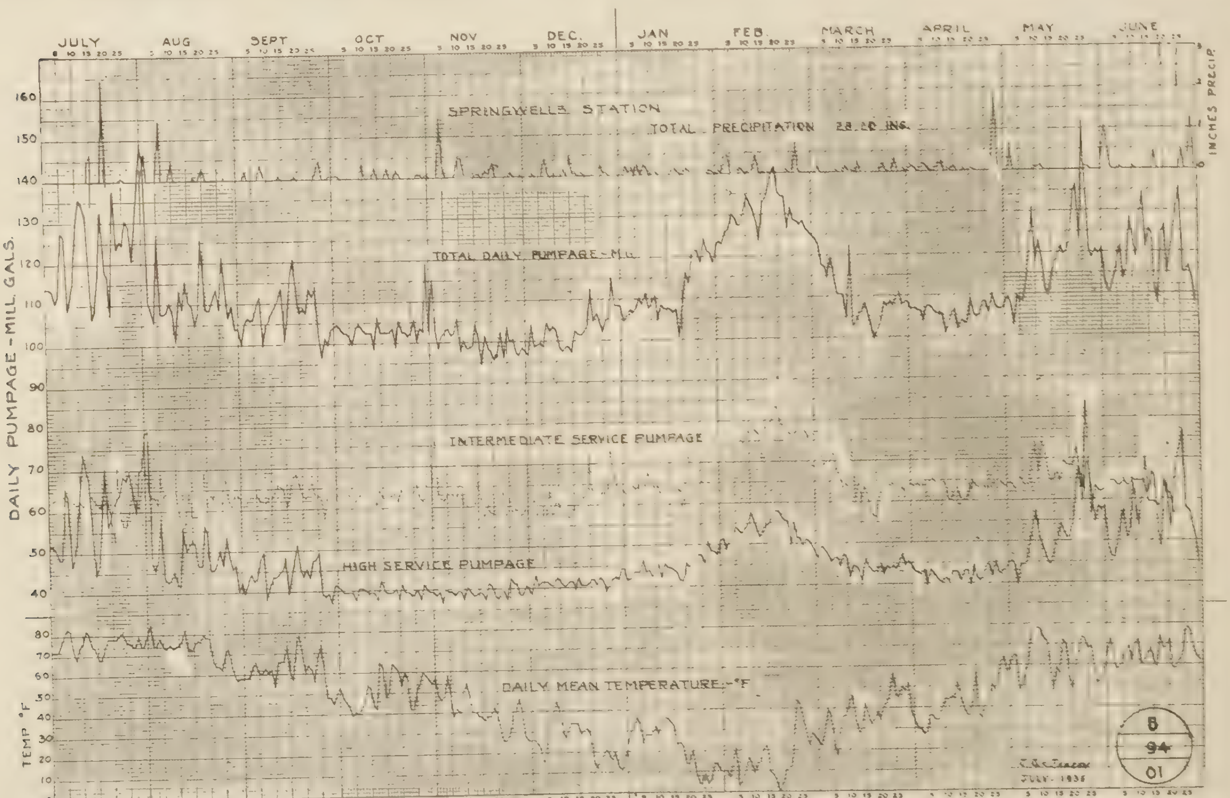


Fig. 8 Pumpage Curves

(These curves show the variation in daily pumpage throughout a year. Curves of daily mean temperature and daily precipitation are included to show how these factors affect water demand.)

TABLE 5 COMPARISON OF BOILER GUARANTEES AND TEST PERFORMANCES

	Guarantee	Test	Guarantee	Test	Guarantee	Test	Guarantee	Test
Steam generated in boiler and waterwalls, lb per hr	30,000	30,000	50,000	50,000	70,000	70,000	90,000	90,000
Coal-burning rate, lb per hr	2,900	2,910	4,900	4,710	6,900	6,600	8,900	8,520
Steam temperature in superheater outlet header, F	688	658	699	666	710	665	663	657
CO_2 at boiler outlet, per cent	12.7	12.95	13.0	12.7	13.6	13.0	14.8	13.85
CO at boiler outlet, per cent	0	0.05	0	0.03	0	0.03	0.3	0.03
Gas temperature:								
Boiler outlet, F	500	470	570	521	640	565	700	600
Economizer outlet, F	374	338	422	384	467	418	528	445
Air-heater outlet, F	187	195	215	223	245	247	273	263
Temperature of air supplied stoker, F	265	255	289	271	312	285	341	298
Combustible in ashpit refuse, per cent	....	11.0	....	11.0	....	11.0	....	10.0
Heat absorbed in economizer, per cent	....	4.0	....	4.5	....	4.75	....	4.75
Heat absorbed in boiler and waterwalls, per cent	....	69.9	....	71.1	....	71.5	....	71.15
Heat absorbed in superheater, per cent	....	10.4	....	11.1	....	11.0	....	10.45
Overall efficiency, per cent	....	84.3	....	86.7	....	87.25	....	86.45

NOTE: Test values for guaranteed loads were interpolated from test curves.

gallons with a maximum day of 151.8 million gallons and a maximum hourly rate of 250 mgd. Of the two pressure systems into which this plant delivers, one designated as "intermediate system" is supplied jointly by Springwells and Water Works Park Stations. A fairly constant amount of this load is taken by Springwells with good load factor, while the other station takes the major portion of the load variations. The other pressure system designated as "high service" is a separate distribution system almost entirely residential in which the demand varies greatly throughout any one day. The minimum pumpage rate in early morning hours in this system is regularly as low as 20 mgd while maximum-demand rates have been recorded as high as 190 mgd in early evening hours in summer when lawn sprinkling prevails. This results in a poor load factor for this system, as shown in Figs. 8 and 9.

The daily pumpage by the low-lift plant is usually nearly equal to the total delivery from the high-lift plant, plus about four per cent used for washing filters. In the operation of this

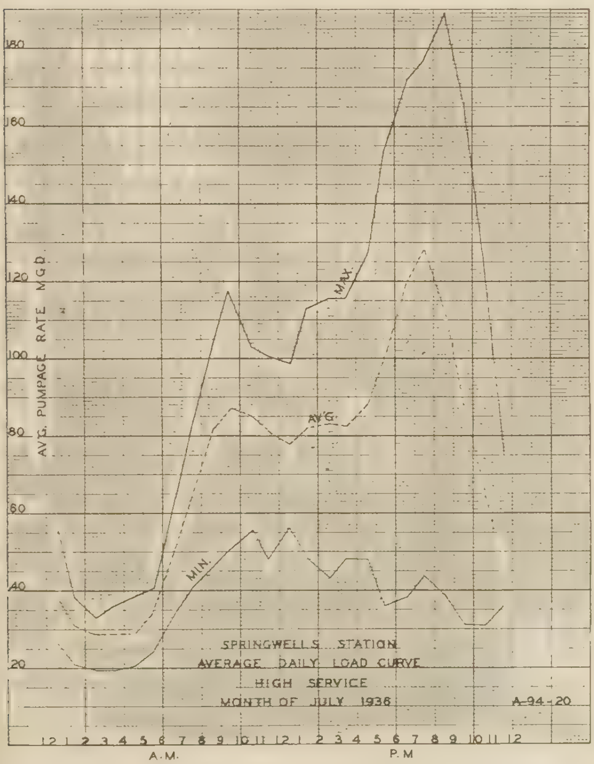


FIG. 9 LOAD CURVE

(This is an average daily-load curve for the high service system for a warm summer month. The high peak load between 8:00 and 9:00 p.m. is due to the demand for lawn sprinkling.)

plant, an attempt is made to keep the delivery at a constant rate to the filters throughout the 24 hours of any one day and variations in the high-lift plant delivery are cared for by the automatic delivery of filtered water to or withdrawal from the 40,000,000-gallon storage reservoirs. Constant delivery to the filters affords favorable conditions for coagulation and filtration and tends to reduce the cost of chemicals to a minimum, but on the other hand, reduces the amount of storage water in the reservoirs to a minimum when the distribution-system demand is at a maximum.

The low-lift pumps draw from the supply tunnel and deliver raw water over the weirs at constant elevation. Variation in head depends on the rate at which the plant is operating. The suction level is drawn lower as the rate increases. At present output, the total dynamic head on the pumps averages 46 to 47 ft and the average overall efficiency from operating records is about 76 per cent, which checks very closely with the comparative acceptance-test efficiencies.

For the fiscal year ending June 30, 1936, the average plant capacity factor was 26.3 per cent with average load factor of 75.8 per cent.

In the 72-in. steel distribution mains there are installed in the station grounds in locations best suited for accurate flow measurement, six $73^1/_4 \times 33$-in. venturi tubes. Mechanical-type flow meters connected to these venturi tubes are installed in the pumping plant in convenient locations.

Pressure in the distribution systems is held within prescribed limits at selected points remote from the pumping plant. A long-distance pressure gage for each pressure system has been installed at a distance of four and one-half miles from the plant. A sending element at the distant point actuates receiving indicators and recorders at convenient locations in the plant. These gages are electrical and the sending and receiving elements are connected by telephone lines.

From acceptance-test curves of low- and high-lift plant pump units there have been developed economy curves to assist the operators in selecting combinations of units to deliver water at the lowest possible cost. These curves Figs. 10 and 11, show that, for all units in both pumping plants, the lowest cost of delivery through pressure ranges prescribed is always at the lowest head which will give satisfactory service. Best economy is secured at the lowest possible total head on pumps regardless of the fact that the efficiency may be much below the maximum that would be secured with the units operating at higher or rated heads.

If care is exercised by operators in making proper selection of pump combinations for existing and predicted loads, it has been determined from economy curves that one million gallons of water can be delivered with power input to motors as follows:

Low-lift plant, kwhr	190
High-lift-intermediate system, kwhr	486
High-lift high-service system, kwhr	735

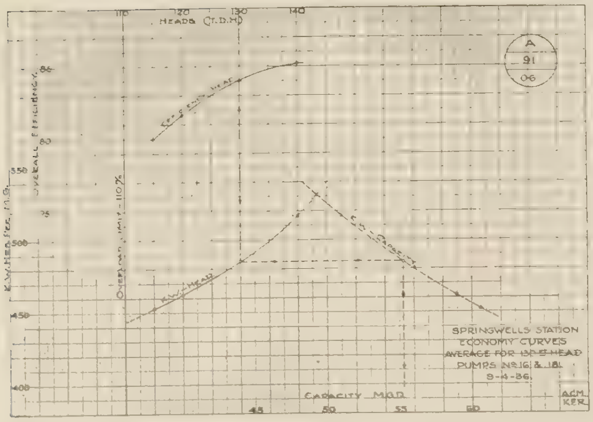


Fig. 10 Economy Curves

(Economy curves for two pumps rated at 50 mgd, 130 ft head. The two curves on the left show cost in kilowatthours per million gallons and efficiency, both plotted against head. The curves on the right show the relation between cost and capacity.)

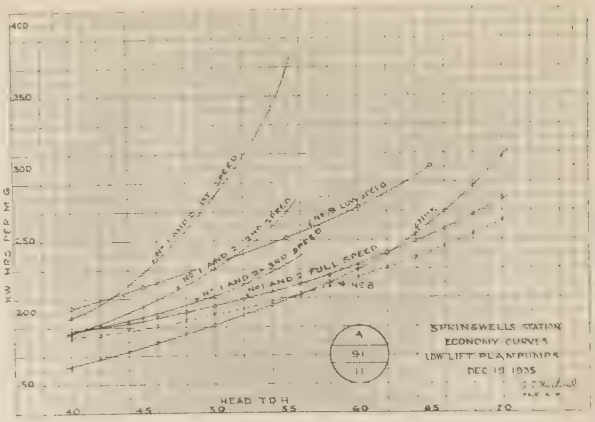


Fig. 11 Economy Curves

(These curves show the relation between total dynamic pumping head and cost of power, in terms of kilowatthours per million gallons, for all of the main pumping units in the low-lift plant.)

The average overall operating efficiency of the high-service system determined from operating records for the fiscal year ending June 30, 1936, was 85.16 per cent. From acceptance tests the average efficiency for the heads developed during this period was approximately 84 per cent.

In the case of the intermediate system, the average efficiency from operating records was 81.42 per cent, and from acceptance tests at heads developed during this period approximately 82 per cent.

The average high-lift plant capacity factor was 19.5 per cent with a load factor of 64.5 per cent.

Power Plant

Station electric loads include power for main pumping units in high- and low-lift plants, filtration plant, all station auxiliaries, and lighting. The maximum hour demand to the present is 10,350 kw. The average demand for the fiscal year ending June 30, 1936, was 4100 kw. During this period the turbo-generator-plant load factor was 69 per cent, capacity factor 24 per cent, and power purchased from stand-by service was 3.21 per cent of the gross output. Except for very short periods, loads were carried with one main 5000-kw unit and one 500-kw auxiliary unit in service. During maximum-hour pumpage in summer and high load on the heating system in winter two 500-kw units have been operated. Similarly in the boiler plant, only one of the two boiler units has been operated except infrequently under special load conditions. The maximum hour load carried to the present by one boiler unit was 97,000 lb of steam per hr which represents a rating of 323 per cent. The average boiler load for the fiscal year ending June 30, 1936, was 51,000 lb per hr or 169 per cent of rating.

Boilers

The boiler units have been operated through varying periods up to a maximum run of three months. With only two units installed and with somewhat limited maintenance forces there is an unavoidable maintenance period required of sometimes one month which makes reserve boiler outage quite high.

Fuels from western Pennsylvania and Harlan County, Ky., have been burned since the beginning of plant operation. A small portion of coal was run-of-mine but the major portion was 2-in. or $1^1/_8$-in. nut and slack. Both of these fuels are low in sulphur and have heat values within limits of 13,800 and 14,600 Btu per lb dry basis. Both may be designated as semicaking, but the Kentucky coal possesses some free-burning characteristics and has ash content of less than five per cent and ash-fusion temperature only slightly above 2500 F. The Pittsburgh district coal has ash content of about 8 per cent and ash fusion never less than 2575 F. With continuous and careful observation by operators both of these coals have been burned successfully in these stokers. The Kentucky coal, although used only since November, 1936, appears to be better suited for the link-grate section of the stoker because of its slightly free-burning characteristics, but the low ash content, the low fusion temperature, and the slagging in the underfeed section is already decreasing boiler runs and increasing stoker-part replacements. The cost of stoker replacement parts from initial operation to the end of 1936, was 1.7 cents per ton of coal burned.

The plant design calls for 350 lb gage 700 F steam at turbine throttle, but in operation the average steam temperature has been 670 F. The air heaters have such small apertures for the passage of gas that, even with superheated-steam soot blowing, some trouble has been experienced in prevention of filling the apertures with slightly caked soot or fly ash. To the present time no air or gas by-passes have been provided, and until such provision is made there remains the possibility of a forced shutdown of units because of this difficulty.

The boiler feed make-up water, which amounts to approximately 1.5 per cent is evaporated before entering the condensate system, and all feedwater is deaerated in the main condensers. The only other treatment used up to now has been sodium sulphite which is introduced into the boiler feedwater at the outlet of the closed heaters for reduction of the last trace of dissolved oxygen.

The internal surfaces of the boilers and the economizers are coated with "Apexior." The boilers have been in service for two years and careful inspection shows no trace of boiler scale and only very minor pitting has been detected at or near the water line of the drums and tubes. The treatment used usually results in a sulphate-carbonate ratio conforming with A.S.M.E. recommendations.

The temperature of stack gases averages only slightly over

TABLE 6 AVERAGE OPERATING TEMPERATURES AT BOILER LOAD OF 60,000 LB OF STEAM PER HR (SUMMER CONDITIONS)

	Temperature F
Gases at boiler exit	545
Gases at economizer exit	402
Gases at preheater exit	235
Feedwater entering economizer	262
Feedwater entering boiler	320
Steam at superheater outlet	665
Preheated air	278

PLANT		DESCRIPTION	MAKER
Low Lift Pumping Plant	Initial Installed Capacity 434-MGD.	Equipment-Initial Installation. (Direct connected vertical shaft units)	
		3-60 MGD.-60 Ft. Head. Centrifugal pump units. 750 H.P. Synchronous motors	Worthington Pump & M. Corp'n.
		3-60 " 50 " " " " " 750 " " "	" " "
		2-30 " 50 " " " " " 350 " Slip Ring Ind. "	"
		2-7.2 " 55-110 " " " " 100-200 H.P. Squirrel Cage Ind. motors	American Well Works.
	Proposed Final Design Capacity 494-MGD	Equipment-Proposed Final Install'n. (Direct connected vertical shaft units)	
		5-60 MGD.-60 Ft. Head. Centrifugal pump units 750 H.P. Synchronous motors.	
		3-60 " 50 " " " " " 750 " " "	
		2-7.2 55-110 Ft. " 100-200 H.P. Squirrel Cage Ind. motors	
High Lift Pumping Plant	Initial Installed Capacity 568-MGD.	Equipment-Initial Installation (Direct connected horizontal shaft units)	
		4-40 MGD. 200 Ft. Head Centrifugal pump units 1725 H.P. Synchronous motors	Worthington Pump & M. Corp'n.
		2-30 " 200 " " " " " 1400 " Slip ring Ind. motors	" " "
		2-50 " 150 " " " " " 1675 " Synchronous "	" " "
		2-50 " 130 " " " " " 1425 " " "	" " "
		2-40 " 130 " " " " " 1200 " Slip ring Ind. "	" " "
		2-17 " 180 " " " " " 700 " Synchronous "	Byron-Jackson Co.
		2-17 " 130 " " " " " 700 " " "	" " "
	Proposed Final Design Capacity 680-MGD	Equipment-Proposed Final Installation. (Direct connected horizontal shaft units)	
		6-40 M.G.D. 200 Ft. Head Centrifugal pump units 1725 H.P. Synchronous motors	
		2-30 " 200 " " " " " 1400 " Slip ring Ind. "	
		4-50 " 150 " " " " " 1625 " Synchronous "	
		2-50 30 " 1425 " " "	
		2-40 30 1200 " Slip ring Ind "	
Power Plant	Initial Installed Capacity 16500 KW.	2-5000 KW Main Turbo-Generators	General Electric Co.
		2-Surface Condensers, 10,000-sq. ft. condense 80,000 #/hr	[illegible]
		3-500 KW Auxilliary Turbo Generators	General Electric Co.
		3-Surface Condensers-800 sq. ft.	[illegible]
		3-400 KW. and 3-50 KW Motor Generators	[illegible]
		1-5000 KW. central station Transformer. 24000/4600 Volt-3 phase.	" " " "
		2-1000 H.P. Boilers. 3 drum-bent tube type. Surface 10,388 sq. ft.	[illegible]
		2-Superheaters. Gas touched-1720 sq. ft. Steam touched-1400 sq. ft.	Superheater Co.
		2-Economizers. Active surface-2,430 sq. ft.	Babcock & Wilcox.
		2-Air Preheaters. 9,980 sq. ft. surface	Air Preheater Co.
		2-Underfed Stokers, motor driven-190 sq. ft.	[illegible]
		2-Forced Draft Fans. Cap-45,000 c.f.m. @ 13.5" water, static pressure	Green Fuel Economizer Co.
		2-Induced Draft Fans. Cap-75,000 c.f.m. @ 11.0" water, static pressure	
		1-Coal Handling System. Cap-75 tons per hour.	Link-Belt Co.
		1-Hydraulic Ash Handling System. Pump Cap-1000 GPM	Allen-Sherman-Hoff
		3-Boiler Feed Pumps (2-motor & 1-turbine driven) Capacities: 300 g.p.m.	Pennsylvania P. & Comp. Co.
	Proposed Final Capacity 27,000	4-5000 KW. Main Turbo-Generator units; Or 2-5000 KW. & 2-7500 KW	
		4-Surface Condensers.	
		4-500 KW. Aux. Turbo-Generators.	
		4-Surface Condensers	
		3-400 KW. and 3-50 KW. Motor Generators.	
		1-5000 KW. Central Station Transformer.	
		4-1000 H.P. Boiler units, complete with Superheaters, Economizers, Air Preheaters, Stokers, Draft Fans & B. Feed Pumps	
		1-Coal Handling System.	
		1-Hydraulic Ash Handling System	

FIG. 12 LIST OF ALL EXISTING MAJOR EQUIPMENT FOR PUMPING AND POWER PLANTS, AND ULTIMATE PLANT EQUIPMENT

200 F, which together with the fairly high values of carbon dioxide in flue gas, results in satisfactory overall boiler-unit efficiencies. Results of carefully conducted acceptance tests throughout the range of loads from 30,000 to 90,000 lb per hr, showed a maximum overall efficiency at 56,000 lb per hr of 87.1 per cent for the complete boiler unit. The average of monthly efficiencies, computed from the operators' logs taken from commercial meters, checks within two per cent with the results of tests made using special and carefully calibrated instruments.

Additional information in regard to temperatures is given in Table 6.

Turbogenerators

The main 5000-kw turbogenerators operate continuously with two-stage bleeding for feedwater heating and evaporation of feedwater make-up. The auxiliary 500-kw turbogenerators are operated continuously with one-stage extraction for station heating. Extraction in summer months is low, the maintaining of hot water for wash and shower rooms being the principal demand. Although all turbines normally operate extracting, acceptance tests in accord with contract terms were conducted with the units operating full-condensing. Because of this, it is impossible to make direct comparison of actual operating results and acceptance-test results. All units were opened and the rotors and stationary blading thoroughly cleaned with light fly-ash blast and were carefully checked for clearances and reconditioned before testing. The turbines when opened had been operated for periods varying from 4000 to 5000 hours and the rotors and stationary blading were partially covered with thin adherent deposits of iron oxide. The deposits were heavier and more adherent in the low-pressure stages.

Acceptance tests, as for all other equipment, were conducted by Department of Water Supply engineers and witnessed by manufacturers' representatives. The turbogenerator units were tested under conditions very nearly as prescribed in the contracts with the one exception that the temperature of the steam instead of being 700 F was 660 to 670 F. Test results with all corrections made to contract conditions gave steam rates at 5000 kw load and 0.8 power factor on main units of 10.03 and 9.96 lb per kwhr and rates at 500 kw for auxiliary units of 13.56 and 13.85 lb per kwhr.

Overall Station Economy

The following economy figures are for the pumping and power plants for the calendar year 1936:

The thermal efficiency of the pumping plant was 16.06 per cent. The fuel rate was 1.136 lb of dry coal per net generated kwhr. The average equivalent evaporation was 12.35 lb of steam per lb of dry coal from and at 212 F. The average plant water rate was 11.91 lb of steam per net kwhr. The electric power per whphr was 0.927 kwhr. The coal required to pump one million gallons 100 ft high for the Springwells Station was 479 lb.

Conclusions

Now that the department operates two stations involving generation of steam or power to operate pumps and purification plants, it would normally be expected that some comparison of operating results secured should be presented. It was, however, considered inadvisable to attempt such a comparison because of lack of detailed operating data for the Water Works Park Station. Just for a general comparison, it may be stated that the average cost of pumping water, exclusive of fixed charges, for the period from April 1, 1935, to December 31, 1936, was \$6.62 per million gallons for Springwells and \$8.13 for Water Works Park. During this period the division of load was approximately, Springwells 45 per cent and Water Works Park 55 per cent of total pumpage. The average costs of purification for the same period have been, Springwells \$2.52 per million gallons and Water Works Park, \$2.98.

Since the Springwells Station has been in operation and even during the first summer while, due to the depression, city demand for water was still low, it was evident that the new station was not only a distinct advantage for normal loads but a real necessity for maintaining distribution-system pressures in all locations in the system during maximum-load conditions.

Much credit is due the general manager, George H. Fenkell, water commissioners, consultants, and other city officials during the period of planning and construction for their continued and untiring efforts which finally produced an essential station as an auxiliary to the lone and old original Water Works Park Station.

BIBLIOGRAPHY

1 "Huge Intake Lagoon Built to Avoid Ice Troubles," by Torris Eide, *Engineering News Record*, vol. 107, no. 13, Sept. 24, 1931, p. 494.

2 "Water Works Intakes of the Great Lakes Region," by Geo. H. Fenkell, *American Water Works Association Journal*, vol. 16, no. 3, Sept., 1926, p. 267.

3 "The Concrete Lining of the Water-Supply Tunnels of Detroit, Mich.," by L. G. Lenhardt, Proceedings, American Concrete Institute, vol. 25, Feb. 12, 1929, p. 152.

4 "Design Features of a 90-ft Circular Low-Lift Pumping Plant," *Engineering-News Record*, vol. 106, no. 12, March 19, 1931, pp. 468–472.

5 "Model and Full-Size Surge Tests on Large Branched Tunnel System of Detroit Water Supply," by A. C. Michael, *Journal American Water Works Association*, vol. 28, no. 3, March, 1936, pp. 295–317.

6 "Selecting Pumping Equipment for a Large Water Plant," by William C. Rudd and Louis E. Ayres, *Engineering News Record*, vol. 111, nos. 15 and 16, October 12 and 19, 1933, pp. 429–433 and 467–471.

7 "Detroit's New Springwells Pumping Station," *Power*, vol. 73, March 24, 1931, pp. 468–471.

8 "Four-step Power Conversion at Springwells," Ibid., vol. 77, September, 1933, p. 470.

Application of Tension-Impact Tests

By G. F. JENKS,[1] WATERTOWN, MASS.

Impact testing as normally performed with notch bars is objectionable because of large errors inherent in the method of test, and especially those due to errors in machining the notch. Notch tensile specimens are more satisfactory being less sensitive to errors of machining or to accidental variations in structure of the material.

In studying tension-impact specimens it was found that materials required a constant energy to rupture independent of the velocity of loading provided certain critical velocities were not exceeded. This critical or "transition" velocity appears to be a fundamental property of a material. Its value varies with chemical compositions and with both preliminary and final heat-treatment, and it also varies with the temperature of test.

The study of "transition" velocity is a sensitive tool in research work, both in the development of processing methods and in physical metallurgy. The tension-impact test is a simple test to determine completeness of processing, and affords the design engineer information both as to the safety of the material and its ability to withstand impact loading.

ALTHOUGH impact testing had aroused sufficient interest to result in a symposium by a national engineering group in 1922,[2] it is little used today. The term receives no mention in the 1936 index of A.S.T.M. Standards of Metals. It is true that this method of testing is designated in some A.S.T.M. specifications, as for example, A63-36, which requires the use of 1640 and 2240 lb tups falling from heights up to $17^1/_3$ ft. The A.S.T.M. Tentative Standards, 1936, does prescribe "Tentative Methods of Impact Testing of Metallic Materials," E 23-34T and includes as an appendix an apology for the method.

Impact tests are prescribed in other specifications and producers of materials publish many data on impact properties at normal and at low temperatures in advertisements of special processing methods or special compositions. Such tests are also widely employed in research work on the properties of materials at low temperatures and to some extent in studying failures.

The significance of the test, however, has been vaguely understood. The design engineer notes it in the selection of materials but makes no direct application of it in the calculation of stress distribution. He considers the ductility as measured by the static tension test to be a measure of the safety of his structure and carefully prescribes elongation and reduction of area in addition to yield and tensile strengths. Impact strength he leaves to the metallurgical engineer as one of those elements included in the factor of safety or, as some express it, the "factor of ignorance."

Two of the main reasons for these conditions are the form of the test specimen and the nature of the test. The sensitive portion of the specimen is the notch. Various forms such as keyhole and V notches are in use. Much has been written concerning the virtues and vices of various notches and methods of machining them. Under stress concentration these notches are extremely sensitive to errors of machining or to differences and irregularities in their surface. In the notched-bar specimen the rupture originates in the notched surface. Stress concentration around tears and irregularities of surface will determine the origin of fracture and the time at which rupture starts. If fracture originates prematurely the energy required will be abnormally low.

The volume of the notch, especially the V type, may be modified considerably by errors in machining the radius of the fillet at the bottom of the notch, and also by tearing the surface of the fillet. The energy required to break the bar varies with the volume of the notch.

Impact tests, as usually employed, are high-velocity bend tests. Stresses across the section under plastic flow are variable in intensity and are difficult to analyze. Most of the energy required is absorbed in plastic working of the metal. With a variable width of notch it is impracticable to predetermine the volume of metal which will receive plastic working. It varies with the yield strength and the yield ratio of the specimen. If a fracture originates around an irregularity of machining or of structure, the results are a measure of surface condition rather than of the ability of the metal to absorb energy under conditions of high velocity loading.

It is not to be inferred that notched-bar impact tests are without significance and that they do not disclose useful properties of materials. Rather, it is concluded that the test is difficult to evaluate and that the errors of tests are inherently large.

At Watertown Arsenal the transverse notched-bar impact tests were abandoned about ten years ago for the reasons just briefly discussed, and a notched tension-impact specimen was substituted. The ordinary Charpy pendulum impact machine is used in the test. The notch is a truncated V with a flat 0.05 in. wide. No particular care is taken in machining the fillet between the bottom and the wall of the notch as the volume of the notch does not vary appreciably with errors in its dimensions. Recent investigations discredit the truncated V notch in favor of a square notch. The specimen has been fairly satisfactory, however, in the development of methods of processing steel, in studying failures of material, and in inspecting purchased materials.

In its research work and in the development of welding technique, the Arsenal has also employed long-notch tensile specimens. Normally the length of a long notch is the gage length of the static tension test specimens. In comparing the energy absorbed in static and dynamic tests, abnormalities in the behavior of certain materials were observed. This led to investigations, the results of which have been published.[3] From this work two fundamental properties of metals were disclosed:

(1) Provided certain critical velocities are not exceeded in tension-impact testing, the energy required to rupture a specimen

---

[1] Colonel, Ordnance Department, U. S. Army, Watertown Arsenal. Mem. A.S.M.E. Commanding Watertown Arsenal since 1932.

[2] Symposium on Impact Testing of Materials. Proceedings American Society for Testing Materials, vol. 22, part 2, 1922, p. 5.

Contributed by the Iron and Steel Division for presentation at the Semi-Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until July 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

[3] "The Relation Between the Tension Static and Dynamic Tests," by H. C. Mann. Proceedings of the American Society for Testing Materials, vol. 35, part 2, 1935, p. 323. Also: "High Velocity Tension Impact Tests," by H. C. Mann, Ibid., vol. 36, part 2, 1936, p. 85.

of given section and length is independent of the velocity of application of load. The energy required to rupture a specimen in tension impact may be calculated from the curve obtained from the results of the static tension test in which the ordinate is the load multiplied by the ratio of the original to the reduced sectional area, and the abscissa is the total elongation.

(2) Beyond certain critical velocities this relationship no longer holds. This "transition velocity" varies with chemical composition and structure and appears to be a fundamental property of metals.

A third fundamental property of tension-impact specimens will be discussed by H. C. Mann in a paper to be presented at the annual meeting of the American Society for Testing Materials.

TABLE 1 EFFECT OF LENGTH OF NOTCH UPON IMPACT PROPERTIES

Notch length, in.	Velocity, fps	Energy: Total, ft-lb	Energy: Per unit volume, ft-lb	Elongation, per cent	Reduction of area, per cent
0.025	10	28.0	22,400		
	20	23.0	18,400		
	28.5	28.0	22,400		
0.05	0	19.5	7,800	17.0	21.0
	10	16.8	6,720	17.5	21.2
	20	19.7	7,880	16.0	18.4
	28.5	23.7	9,480	18.0	22.0
0.1	0	19.5	3,900	19.0	23.0
	10	19.5	3,900	19.0	24.0
	20	23.0	4,600	18.0	23.4
	28.5	19.5	3,900	19.0	24.0
0.2	0	28.0	2,800	39.0	40.0
	10	32.0	3,200	38.0	37.2
	20	29.0	2,900	40.0	42.4
	28.5	28.0	2,800	38.5	41.0
0.4	0	58.0	2,900	39.0	53.6
	10	57.5	2,875	41.5	53.6
	20	58.5	2,925	38.3	54.8
	28.5	59.8	2,990	39.0	54.6
0.8	0	115.0	2,875	33.5	57.4
	10	115.0	2,875	32.8	57.4
	20	108.0	2,700	34.5	57.4
	28.5	117.0	2,925	33.0	57.4
1.0	0	142.0	2,840	33.0	57.8
	10	140.0	2,800	33.0	57.8
	20	145.5	2,910	35.0	57.8
	28.5	140.0	2,800	33.0	57.8

In these concepts of impact testing, the velocity factor is emphasized. This is as it should be. This "transition velocity" is a fundamental property of metals as much as yield strength, tensile strength, and ductility. The impact strength in foot-pounds is a derived value which can be calculated from other primary values. Only when the transition velocity is exceeded does the impact strength become of interest to the metallurgist or the design engineer. Unfortunately, impact-testing machines available in the past have been operated at fixed speeds of 11–17 fps and the form of test specimens has emphasized stress concentration rather than rate of application of load.

Within certain limits the energy absorbed by a given specimen is independent of velocity; it follows that the impact value is independent of the type of machine employed. This is shown by experimental data in which energy values calculated from tests made on static machines are duplicated in machines of both the pendulum type and of the rotary type. The relationship holds for short and long notches.

As a corollary of constant energy, it should follow that the ductility of material is independent of the velocity of test. This accords with experimental data.

Table 1 illustrates these conclusions. The material used was a 1-in. rolled bar of 1035 steel (K-20) received in the annealed condition,[4] and renormalized at 1650 F after holding 3 hr. The data were obtained on a pendulum-type machine, except that the values for zero velocity are computed from the results of the static-tension testing machine. The diameter of notch of the specimen was 0.252 in. The transition velocity of this material in the normalized condition is in excess of 28.5 fps.

The properties of metals for velocities of application of loading greater than the transition velocity is not within the scope of this study. It is sufficient to state that the work required to rupture falls off rapidly for velocities beyond the critical one.

Experimental data indicate that for notches from 0.2 in. long to the gage length of standard tensile specimens, the transition velocity is independent of the notch length.

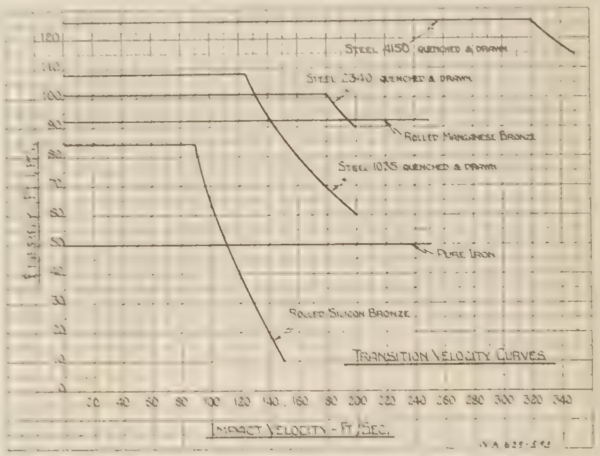


FIG. 1

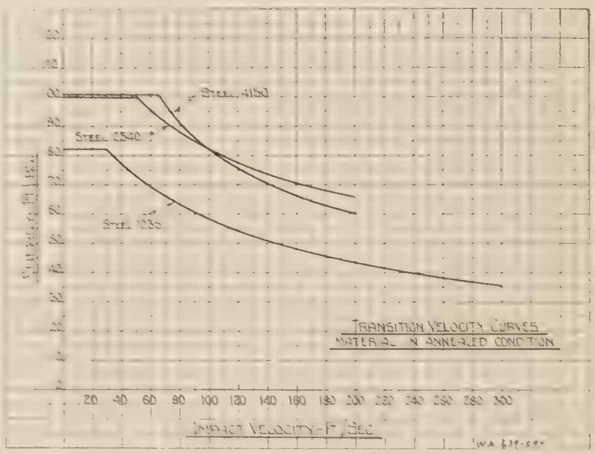


FIG. 2

The transition velocity varies with composition of the metal as shown in Fig. 1.

The transition velocity varies with heat-treatment. Fig. 2 shows values for some materials in the annealed condition, whereas in Fig. 1 the values are given for the quenched and drawn condition. A comparison of Figs. 1 and 2 indicates the change in this transition velocity with structure. The tests were made on material from the same bar of the compositions given. Heat-treatment was the only variable.

Table 2 shows the change in transition velocity for a bar of 1035 steel (K-20) air-cooled from 1700 F (held 3 hr), water-quenched from 1550 F (held 1 hr), and furnace-cooled from the temperature specified after holding 3 hr.

[4] For a history of this material see "Report on Low Temperature Impact Tests," Proceedings American Society for Testing Materials, vol. 36, part 1, 1936, p. 132. Heat-treatment of the material as received is referred to on first page of report.

Fig. 3 shows variations in transition velocity as a function of draw temperature.

Some materials are subject to temper brittleness. In the brittle condition these materials apparently possess transition velocities below those ordinarily used in impact testing, and impaired impact properties are disclosed by ordinary tests. A study of critical velocities of loading presents a different angle to the problem of brittleness, as indicated in Table 3. The data were obtained from a bar of chrome-nickel steel (WD 3435) oil-quenched from 1450 F (held 2 hr). One group of specimens was then oil-quenched from 1160 F (held 2 hr) and the other group furnace-cooled after holding 2 hr at the same draw temperature. The diameter of specimen at the notch was 0.357 in. For zero velocity the energy was calculated from the static tests.

TABLE 2 EFFECT OF TEMPERING UPON IMPACT PROPERTIES

(Length of notch 1.00 in.; diameter 0.252 in.)

Draw temperature, F	Velocity, fps	Total energy, ft-lb	Elongation, per cent	Reduction of area, per cent
400	28.5	80.6	22.0	58.4
	50.0	80.6	23.2	59.2
	80.0	76.0	23.2	58.8
	100.0	67.5	23.7	60.8
	125.0	58.0	25.2	61.2
	150.0	52.0	27.5	62.8
600	28.5	95.0	22.0	61.8
	100.0	91.0	23.6	62.8
	150.0	77.0	26.4	65.6
	200.0	68.0	28.0	67.0
	250.0	64.3	29.0	70.0
800	28.5	81.2	22.2	57.8
	100.0	83.5	24.2	60.8
		81.0	23.2	58.4
	125.0	76.5	23.5	61.8
	200.0	56.0	27.8	66.6
	250.0	49.0	27.8	68.4
1000	30.0	105.3	20.0	64.2
	50.0	99.8	21.2	65.0
	100.0	108.2	20.0	64.2
	125.0	108.8	19.8	66.0
	150.0	85.0	23.0	69.0
	200.0	61.0	25.0	72.0
1200	28.5	85.0	26.5	65.6
	100.0	85.0	26.8	66.0
	150.0	78.0	26.8	67.0
	200.0	57.0	31.3	70.0
	250.0	44.1	29.6	71.0

TABLE 3 IMPACT PROPERTIES OF MATERIALS SUBJECT TO TEMPER BRITTLENESS

Length notch, in.	Impact velocity, fps	Oil-quenched total energy, ft-lb	Furnace-cooled total energy, ft-lb
0.05	0	73.5	66.5
	10	72.6	62.6
	20	65.5	60.5
	28.5	65.3	58.8
1.4 (Standard gage length)	0	432.0	416.0
	10	...	372.0
	15	430.0	...
	20	395.0	336.0
	25	345.0	...
	28.5	289.0	320.0

For the material quenched from the draw, the transition velocity is near the velocity of standard impact machines, whereas for the furnace-cooled bars the transition velocity was well below that velocity. The difference in transition velocities is not great but of such nature that the ordinary impact test brought it out. If the transition velocity rather than the impact strength be considered, the use of this material however heat-treated must be questioned for some applications. In such cases of low transition velocities, the impact strength as measured in foot-pounds is no indication of the safety of a structure subject to impact loading.

The impact strength of cast steels is sensitive to diffusion heat-treatments as illustrated in the case history of a casting of the following chemical composition: Carbon 0.38, manganese 0.53, silicon 0.20, sulphur 0.022, phosphorus 0.018, molybdenum 0.30, vanadium 0.09 per cent. The original heat-treatment was: held 8 hr at 960 C, air-cooled; held 6 hr at 850 C, furnace-cooled; held 4 hr at 860 C, water-quenched; held 6 hr at 700 C, furnace-cooled. After this treatment the impact strength, measured upon a truncated V notch in tensile impact, was 7.5 ft-lb. After a complete reheat-treatment identical with the first, the impact strength was not sensibly changed (8.8 ft-lb). After a diffusion treatment in which the material was held 25 hr at 1150 C (air-cooled) and then retreated through approximately the same cycle as before, the impact strength was raised to 30.5 ft-lb. In this case the ductility varied in much the same proportion. The transition velocity was not determined, but from a comparative study of this and other castings of similar composition and treatment, it is apparent that the transition velocity of the material as originally treated was well below 15 fps, whereas after high-temperature treatment the critical velocity is well above that figure. It is believed that further investigation will show that the transition velocity is extremely sensitive to the diffusion treatment of steel.

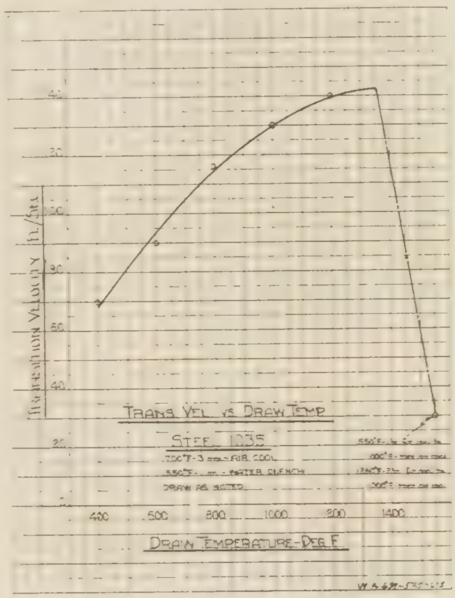


Fig. 3

Warner[5] reports that for one composition of steel plates for welding a stress-relieving treatment (600 C) raised the transition velocity from 30 to over 150 fps without appreciable change in energy recorded by the test. For another composition, the stress-relieving treatment increased the energy to rupture by about 15 per cent, whereas the transition velocity was increased from 37 to 100 fps.

It has long been known that the impact strength of materials was affected by low temperatures. In the reference in footnote 4 of this paper results are disclosed on a 1035-steel (K-20) including tension-impact results (see Fig. 6 of that reference). As these results did not include a satisfactory correlation between tension-impact and V-notch and keyhole-notch transverse tests, a more complete investigation of the material was made. The material used was the same lot of K-20 steel, except that it was heated to 1650 F, held 3 hr, and air-cooled. The departure from the original treatment was accidental. All results at low temperatures were determined while the specimen was held in a bath at prescribed temperature.

[5] "Arc Welding of Structural Alloy Steels," by W. L. Warner, Trans. A.S.M.E., vol. 58, no. 7, 1936, p. 515.

The properties of this material as measured by static tension tests are plotted in Fig. 4 for a 0.252-in. specimen (1 in. gage length).

In Fig. 5 are shown in full line the load-elongation curves for

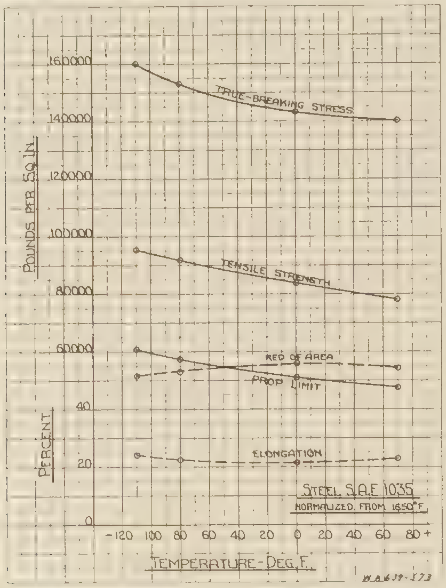


FIG. 4

specimens with two lengths of notches and at the extreme temperatures used. In the upper curves for each temperature the ordinate is the load multiplied by the ratio of the original section

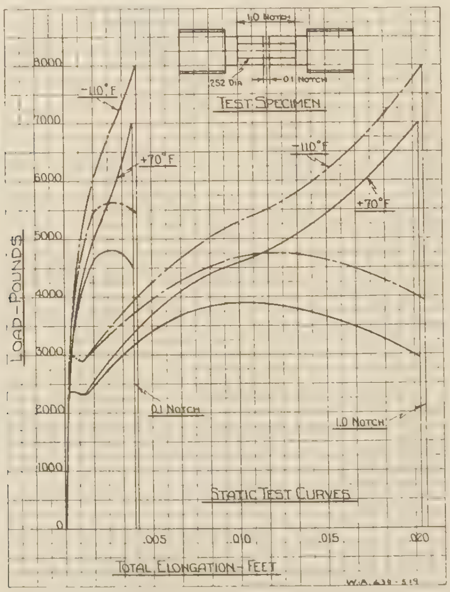


FIG. 5

to the reduced section. The energy for zero velocity is calculated from this curve. The true breaking stress of Fig. 4 is proportional to the maximum ordinate of this curve.

The results of impact tests are tabulated in Table 4. The results of tests are shown graphically in Fig. 6.

If the energy absorbed is reduced to energy per unit volume of

TABLE 4 LOW-TEMPERATURE IMPACT TESTS

Temp.	Vel.	Elon.	Red.	Energy, ft-lb Total	Energy, ft-lb Per unit, vol.
1.00 notch					
+70..........	Static	23.2	54.5	80.0	1600
	28.5	22.5	54.0	80.0	1600
0..........	Static	21.8	55.2	85.2	1704
	28.5	21.8	55.2	86.7	1734
−80..........	Static	22.7	52.4	100.0	2000
	28.5	22.5	54.0	95.0	1900
	15.0	21.5	51.9	100.0	2000
—110..........	Static	24.1	52.0	108.0	2160
	28.5	18.6	52.4	70.0	1400
	20.0	19.6	51.4	87.0	1740
	15.0	22.0	52.4	100.0	2000
	10.0	23.5	52.0	108.4	2170
0.10 notch					
+70..........	Static	19.0	28.0	22.6	4520
	28.5	17.0	25.4	22.7	4540
0..........	Static	19.0	23.0	25.0	5000
	28.5	17.0	22.0	24.8	4960
—80..........	Static	20.0	22.6	28.0	5600
	28.5	13.0	11.0	24.8	4960
	15.0	..	..	27.6	5520
—110..........	Static	22.0	25.4	30.0	6000
	28.5	6.0	3.4	17.0	3400
	20.0	10.0	11.0	21.4	4280
	10.0	..	..	29.8	5960
0.032 notch					
+70..........	28.5	..	..	23.0	14370
0..........	28.5	..	..	22.0	13740
—40..........	28.5	..	..	17.0	10620
	20.0	..	..	26.0	16250
—80..........	28.5	..	..	11.4	7130
	15.0	..	..	25.3	15800
	10.0	..	..	32.2	20120
—110..........	28.5	..	..	10.3	6400
	15.0	..	..	23.0	14400
	10.0	..	..	28.0	17500
	5.0	..	..	31.0	19400

the notch, the results (see Fig. 7) are of great interest; they illustrate the effect of stress concentration upon the transition velocity. This is shown directly in Fig. 8. In Fig. 9 the results of the tension-impact tests are compared with those referred to in footnote 4 of this paper. It is to be noted that the very short

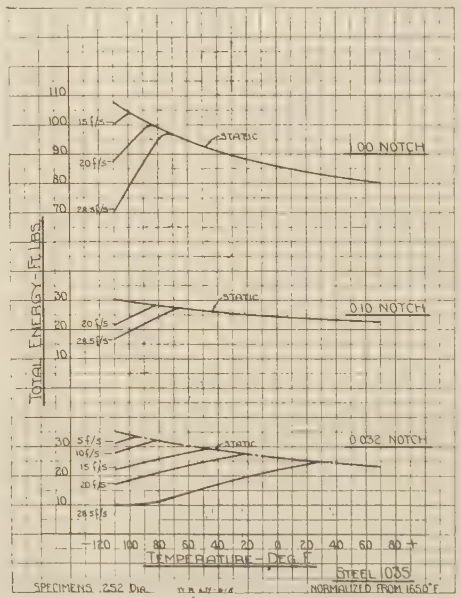


FIG. 6

notched-tension specimen possesses a sensitivity similar to that of the V notch. Experimental work is being conducted on an even shorter notch. The advantage of the tension specimen lies

in furnishing information by which an optimum impact-energy curve can be constructed and by which the effect of velocity of loading can be analyzed. Such information should furnish a clue to the physical metallurgist in the study of the structure of metals as affected by temperature. The concept of critical velocities of loading should clarify some of the impact phenomena which have been a source of difficulty to design engineers and metallurgists. It offers an extremely sensitive method of test to judge the effect of changes in processing and composition of metals used under extreme conditions.

In tension-impact testing the energy values are sensitive to nonhomogeneities of the test specimen and especially to those located near the surface. By examination of the fracture it can be determined whether abnormal values are due to unusual defects such as errors in machining, internal cracks, slag, nonmetallic particles or other defects of a local nature, or to improper or insufficient heat-treatment. Abnormal values of a discontinuous nature not representative of the material may be recognized and discarded. Results of tests are not highly sensitive to errors or irregularities in machining. By careful examination of the

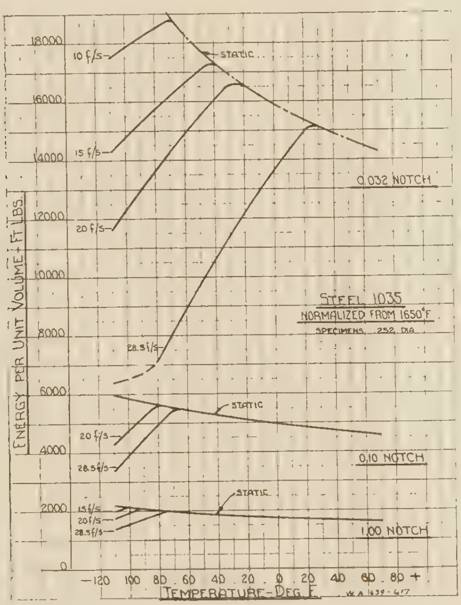


FIG. 7

fracture, rather reliable opinions as to irregularities and incompleteness of processing can be formed. The fracture of the transverse (notched-bar) specimen is more difficult to interpret and yields less information as to the quality of the metal. The quality of the machined surface of the notch is overemphasized. The errors of testing are of smaller magnitude in the tension specimen. In the tables included in this paper, all tests made in the series are recorded. Of course abnormally low results are obtained. The cause is generally apparent in the study of the fractured surface.

Conclusions

Impact strength of materials, within certain limits of velocity application of loading, is a derived value.

The transition velocity is a fundamental property of metals. The ability of metals to absorb energy is limited beyond a critical velocity of application of stress.

Tension-impact tests permit the separation of this fundamental property from the record of impact strengths and the determination of the optimum values.

In research, the tension-impact test is capable of extreme sensitivity to structural changes in metals.

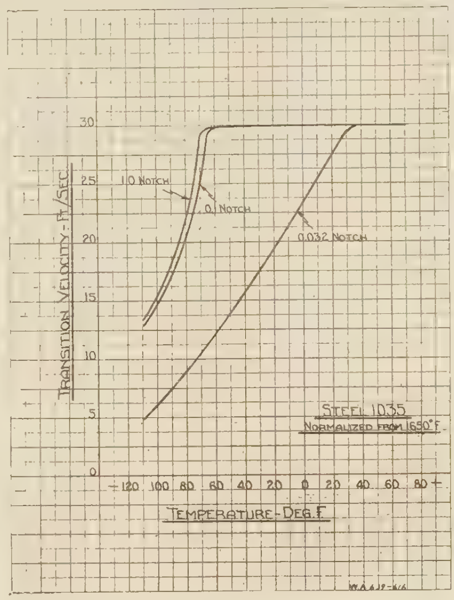


FIG. 8

New problems are presented to the physical metallurgist to explain why metals are sensitive to the velocity of loading. A new method is offered to study physical phenomena and technological processing.

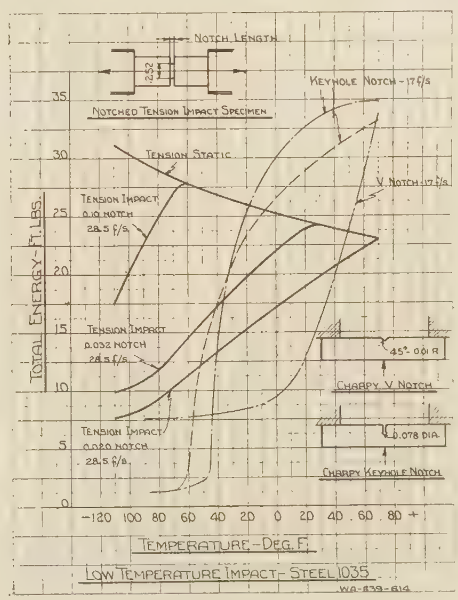


FIG. 9

The introduction of the concept of transition velocity into impact testing gives the design engineer another factor to consider in the selection of materials. Materials of given physical

properties as expressed in strength and ductility, are not interchangeable as to use. If the velocity of application of loading is a factor, the transition velocity of the material becomes one of the most important elements in the selection of chemical composition of the material and its heat-treatment.

If the tension-impact test is to be used as an inspection tool to determine the completeness of processing, the velocity of test should be just under the transition velocity inherent in well-processed metal of the composition and structure specified.

Acknowledgment

The experimental work recorded in this paper was carried out by H. C. Mann, senior materials engineer at the Watertown Arsenal. His studies and reports are the basis of this study.

Maintenance of High-Speed Diesel Engines on the Canadian National Railways

By I. I. SYLVESTER,[1] MONTREAL, CANADA

This paper sketches the application of Diesel-electric equipment to rail traction on the Canadian National Railways, and deals particularly with experiences in the maintenance of high-speed Diesel engines since 1925. The circumstances surrounding the early application of this type of motive power are briefly explained. Problems of repair by steam-locomotive maintenance organizations are outlined. The important records pertaining to performance and measurements of wear occurring on various parts of Diesel engines are described. Typical examples of records developed in handling pistons, cylinders, and crankshafts, which were employed in arriving at a systematic handling of these parts, are illustrated. This is followed by an explanation of curves covering the average rate of wear found on different groups of engines taken from records extending over many years. Brief reference is made to maintenance methods developed in steam-locomotive service and advantageously extended to Diesel repairs. These include illustrations on electric and acetylene welding, together with some experiences with hard chromium plating, employed to extend the life of active engine parts. The paper is concluded with an explanation of the trends of various factors which make up the cost per car-mile of Diesel-engine operation, and relate particularly to engines which have seen considerable service.

The purpose of this paper is to present the results of experience gained in the maintenance of high-speed Diesel engines on the Canadian National Railways. Some 12 years ago the necessity of handling economically traffic of small proportions was recognized, and therefore careful studies were made of existing types of motive power from which it was decided that the self-propelled car using an internal-combustion engine was most suitable for the intended service. The lightweight high-speed Diesel engine, because of its compact size and relatively high thermal efficiency, was chosen for the power plant.

In the beginning, the object was not to provide a de luxe service beyond that offered by steam trains, but rather to substitute Diesel-electric rail cars on runs then operated at little or no profit, and on lines having relatively light traffic. In the light of recent developments on other railroads of high-speed Diesel-powered trains with streamlining, air conditioning, and luxurious appointments, the original venture of the Canadian National appears rather modest.

The choice of lightweight high-speed Diesel engines for rail service was extremely limited in those days, although it has expanded tremendously during the intervening years. Today we are operating rail cars and locomotives ranging from 200 to 1330 bhp. However, this particular paper will deal only with the maintenance of three principal groups of rail-car engines of from 200 to 350 hp, comprising 26 units which have run over ten million miles in passenger service. These engines were placed in service in 1925, 1927, and 1930, and even though they include improvements evolved over a five-year period, their maintenance problems are almost identical.

Soon after the commencement of Diesel-electric rail-car service, it was recognized that the oil-electric car offered great possibilities for economical operation and high availability, provided a satisfactory program for maintenance could be worked out. The lack of experience and knowledge on the part of those called upon to handle the engines, and of the designer and builder, regarding operating conditions, was a serious handicap in the early days. The seniority system, commonly followed in railway organizations, sometimes mitigated against the selection of the most capable men. Also the locomotive-shop staff had not previously been called upon to perform the type of work required in maintaining the fine working clearances of the wearing parts. However, these conditions have been quite general on railroads on this continent and are mentioned here only because they had such an influence on the amount and type of maintenance required.

The most desirable condition is found in large numbers of identical equipment, centrally located, as expert supervision can be provided and the staff soon becomes accustomed to the new routine. The other extreme is found in rail-car service where the units are operated over an extremely wide territory, which interferes with efficient training and seriously affects availability of the equipment due to deadheading to and from a centrally located repair point. This latter condition applies particularly on the Canadian National Railways, and the maintenance methods which follow were developed to cope with this situation. All these problems have demanded as much attention as the technical difficulties—possibly more.

A general arrangement showing sections through the types of engines to which this paper applies in particular is shown in Fig. 1. They are four-cycle, direct-injection engines of both British and American manufacture, the original research work having been carried out by the Wm. Beardmore Company at Glasgow prior to 1924 and the later development by the Westinghouse Company at their South Philadelphia plant. The crankcases of these engines are of cellular type, arranged for separate cylinder liners and made of cast steel. The crankshafts are supported in main bearings between each cylinder. Collar studs hold the individual cylinder heads and liners to the crankcase, the main bearings being attached to the crankcase in a similar manner. The crankshafts are of carbon, nickel,

---

[1] Special Engineer, Operation Department, Motive Power and Car Equipment Sections, Canadian National Railways. Mr. Sylvester was educated at Vancouver, B. C. He served a five-year apprentice course, which included technical training, with the Canadian National Railways and then spent two years in the mechanical-engineering department, testing locomotives and appliances with the dynamometer car. His first experience with railway Diesel equipment was in 1925 when the original Beardmore engines were installed and a record-breaking run was made from Montreal to Vancouver. Since then his work has been directly associated with Diesel-equipment construction and maintenance. He was transferred to Montreal in his present capacity in 1931.

Contributed by the Railroad Division for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until July 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

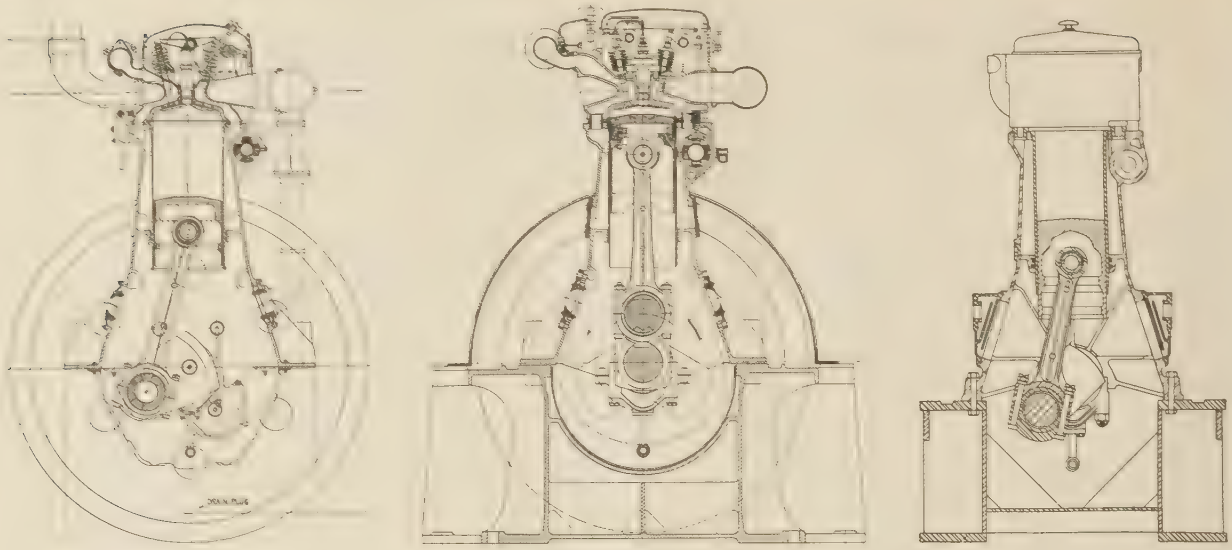


Fig. 1 Sections Through High-Speed Diesel Engines of From 200 to 350 Hp Used on the Canadian National Railways

and chrome-nickel steel forgings machined all over and drilled for pressure lubrication from the main journals to the crankpins. Cast-aluminum cylinder heads with steel valve seats to accommodate dual inlet and exhaust valves are also used on all these engines. Each head carries its rocker-arm mechanism and a single atomizer which is located at the center of the head where it is easily removed. Aluminum pistons, hollow floating wrist pins, and forged-steel connecting rods are also features of these engines. The development of crank end bearings for the connecting rods has been of considerable interest and will be dealt with later.

The cast-steel crankcase and underbed of thin section, together with rather extensive use of aluminum for such parts as pistons, cylinder heads, and gear cases have resulted in weights between 16 and 24.2 lb per bhp for these engines, which is in the lightweight class for rail service. The essential particulars of these units, which were the subject upon which maintenance investigations were carried out between 1925 and the present time, are given in Table 1. These include two columns of figures

TABLE 1 PRINCIPAL PROPORTIONS OF THE DIESEL ENGINES

	Minimum	Maximum
Cylinder bore, in.	8	9
Stroke, in.	12	12
Brake mean effective pressure, lb per sq in.	77	82.5
Maximum cylinder pressure, lb per sq in.	750	800
Diameter of main bearing, in.	5.00	5.00
Length of main bearing, in.	3.70	4.65
Diameter of crankpins, in.	4.75	5.00
Effective length of crankpins, in.	2.29	4.04
Ratio of shaft diameter to cylinder bore	0.555	0.575
Ratio of wrist-pin diameter to cylinder bore	0.315	0.322
Ratio of piston length to cylinder bore	1.4	1.9
Ratio of connecting-rod length to cylinder bore	2.43	2.21
Total weight of connecting rod, lb.	37.94	70.19
Weight of crank end of connecting rod, lb.	26.38	54.09
Weight of wrist-pin end of connecting rod, lb.	11.56	16.11
Weight of piston, lb.	18.19	35.00
Number of pressure rings	4	6
Number of scraper rings	1	3

showing the maximum and minimum sizes, weights, and conditions. The tabulation of the extremes in Table 1 indicates the design limits of the principal rotating and reciprocating parts around which most of the maintenance problems have centered.

The first feature of our maintenance consists of daily reports made out to show the fuel, lubricating oil, and other supplies used, mileage operated and load hauled, together with any trouble experienced during operation, and finally the repairs and inspection which are made daily. These data are compiled monthly to show the average condition obtaining for each car and, as all the equipment is included in this report, it permits the individual maintainer to compare his performance with that of others. This report also shows any troubles which occur with such frequency as to warrant investigation, thus keeping problems in order of their importance before the supervising staff. An analysis of these records over extended periods of operation also indicates any inherent weakness which can be remedied in new designs.

In a general way the practices developed are a combination of railway maintenance ideas and those used in the repair of gasoline engines. Many of the methods employed are quite in line with those generally accepted in fleet operation of trucks and busses. In fact, much inspiration has been drawn from this source when grappling with the more difficult problems. In these installations engine size and weight have been kept to a minimum with the result that provision for successive wear and remachining is not generally made to the same extent as in steam-locomotive work. One principal difference lies in the rather extensive use of welding and, of late, chromium plating as a means for reconditioning wearing parts. Fusion welding, as developed in steam-locomotive service, is now being used extensively in Diesel-engine repairs and much progress has been made in recent years in the use of the electric arc and acetylene flame for the building up of worn parts as well as repairing fractures. Good results were not obtained in this new application without overcoming several technical difficulties because the original development on the railway had to do with structural-steel plates and boiler work in which the metal was quite readily welded. However, in the repair end, large varieties of special metals had to be dealt with and in many instances heat-treatment to regain physical properties of the finished part became a problem.

Considerable ingenuity has been required to develop successful welds on such parts as pistons, cylinder liners, and valve gear. The service engineers of companies which supply welding materials have been of great assistance in the development of suitable welding rods for this work and in providing instructions for their satisfactory use. This process is now responsible for reduction in our maintenance costs and some descriptions of unusual repairs by this method are given under various headings which follow.

Within the last year or so we have been investigating the merits of hard chromium plating in an effort to lower the rate of wear on certain parts and also as a means of regaining the original size where possible. Worn surfaces on pins and journals of crankshafts, wrist pins, cylinders, and various other small parts have been built up with chromium and satisfactorily salvaged. This type of plating must not be confused with the decorative plating which is used more or less in the form of a lacquer to preserve the copper-nickel plating underneath, as it is applied directly to the base metal. We are using thicknesses varying from 0.003 to 0.015 in., depending on service conditions. Excessively thick plates are not found desirable and, for that reason, the original sizes are not always regained. Ordinarily, although sufficiently tough and adherent for bearing conditions, this plate will not endure excessively high unit pressures or shock. For example, in a Brinell test, the high-pressure load of the ball in making the impression will crack the plate and the reading will be practically in line with the base metal underneath. We have taken readings on plated parts with the Firth diamond tester which makes a small impression in the plate and is not affected by the hardness of the base metal. When these readings are converted into the Brinell scale they range from 650 to 900, which is considerably harder than any bearing surface usually encountered.

Our work so far has been limited to steel parts and some fine examples of hard, smooth surfaces with the plate varying only around one-half thousandth have resulted. The shape and placing of the anodes have a very marked influence on the regularity of the plate, and, when these conditions are well understood, it is possible to return the part to service without machine work. It is desirable, however, to grind and polish the finished piece to insure regularity of the bearing surface. When this finishing is carefully carried out, a hard, low-friction, wear-resisting surface is produced and the service to date indicates that long life can be expected from these parts. The mechanics who are handling these plated parts are very much impressed with a journal which can be rubbed with a file without destroying its finish. In the plating, the condition of the surface of the base metal is reproduced in the finest detail and it is, therefore, necessary that the part be very carefully and accurately ground

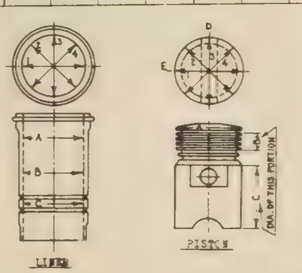
CANADIAN NATIONAL RAILWAYS

OIL ELECTRIC CARS

RECORD OF PISTONS AND LINERS

Car No. 15829
Eng. Type Beardmore-Six
Eng. No. ....
Date ....
Miles ....

		LINERS				PISTONS				PISTON CLEARANCE	
		1	2	3	4	1	2	3	4	D	E
1	A	8.280	8.281	8.281	8.281	8.215	8.216	8.218	8.217	.063	.065
	B	8.251	8.254	8.251	8.254	8.221	8.220	8.228	8.225	.023	.030
	C	8.254	8.250	8.247	8.250	8.232	8.235	8.235	8.234	.012	.022
2	A	8.256	8.258	8.255	8.256	8.213	8.212	8.219	8.214	.036	.043
	B	8.255	8.253	8.254	8.256	8.219	8.220	8.225	8.222	.029	.036
	C	8.253	8.251	8.252	8.254	8.232	8.235	8.238	8.235	.014	.021
3	A	8.284	8.285	8.282	8.282	8.215	8.212	8.219	8.214	.063	.069
	B	8.256	8.253	8.259	8.257	8.221	8.223	8.229	8.223	.030	.035
	C	8.253	8.253	8.251	8.253	8.231	8.235	8.241	8.233	.010	.022
4	A	8.275	8.275	8.268	8.273	8.209	8.214	8.217	8.214	.051	.066
	B	8.257	8.257	8.252	8.253	8.219	8.224	8.226	8.223	.026	.038
	C	8.254	8.254	8.248	8.250	8.230	8.235	8.240	8.235	.008	.024
5	A	8.270	8.272	8.271	8.269	8.215	8.218	8.217	8.212	.054	.055
	B	8.254	8.254	8.252	8.253	8.223	8.225	8.226	8.223	.026	.031
	C	8.253	8.253	8.247	8.250	8.235	8.235	8.237	8.236	.010	.018
6	A	8.271	8.269	8.269	8.268	8.216	8.218	8.219	8.216	.050	.055
	B	8.253	8.253	8.255	8.256	8.222	8.223	8.225	8.222	.030	.031
	C	8.250	8.250	8.253	8.254	8.231	8.235	8.236	8.232	.017	.019
7	A										
	B										
	C										
8	A										
	B										
	C										



REMARKS

Ring grooves badly worn on all pistons, especially on exhaust side. Land broken between #1, #2 and #3 ring grooves on #1 piston.

RECORDED AT:- Edmonton
RECORDED BY: - I.I.S.

CANADIAN NATIONAL RAILWAYS
OFFICE OF CHIEF ELECT. ENGR.
MONTREAL, QUE., DEC. 30, 1930

Fig. 2 Record of the Rate of Piston and Cylinder-Liner Wear

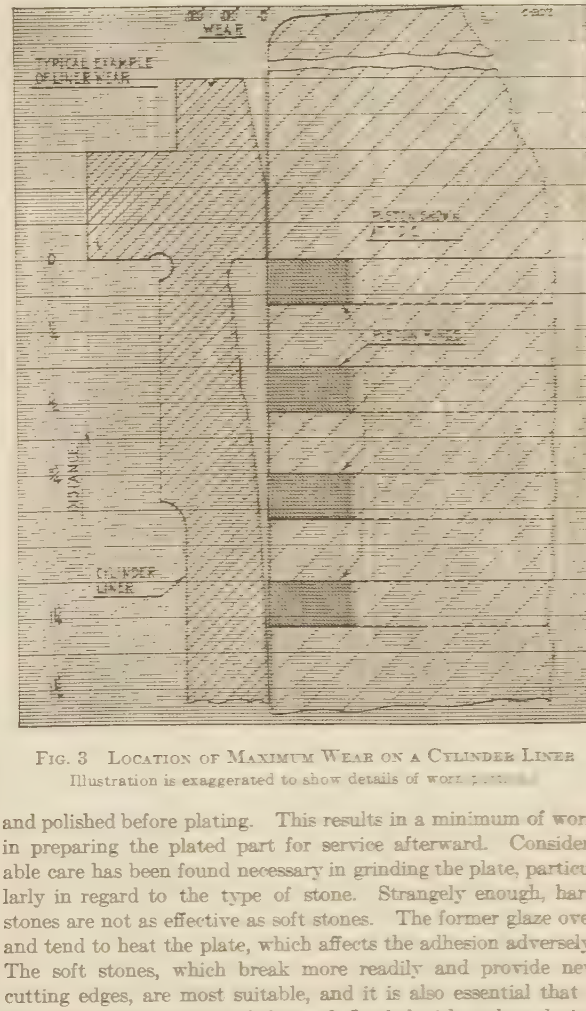


Fig. 3 Location of Maximum Wear on a Cylinder Liner
Illustration is exaggerated to show details of worn

and polished before plating. This results in a minimum of work in preparing the plated part for service afterward. Considerable care has been found necessary in grinding the plate, particularly in regard to the type of stone. Strangely enough, hard stones are not as effective as soft stones. The former glaze over and tend to heat the plate, which affects the adhesion adversely. The soft stones, which break more readily and provide new cutting edges, are most suitable, and it is also essential that a very light cut be taken and the work flooded with coolant during the process. The time necessary to remove the excessive plate is such as to warrant great care in preparing the parts and in bringing them up to a diameter only slightly in excess of the required size. This, of course, requires a complete knowledge of the rate at which the plate is being deposited, so the thickness can be judged on a time basis.

Cylinders

The cylinders in these engines are in the form of relatively thin tubing, accurately machined all over, and are snugly fitted in the crankcase. They are of the wet type, being surrounded by cooling water, and the joint at the bottom is made by means of rubber rings. This construction, which is now generally accepted for this type of engine, is well suited to maintenance because of the ease with which the cylinder can be removed for repairs or replacement.

Our lack of information regarding the rate of wear on cylinders

and pistons of rail-car engines, some ten years ago, resulted in the introduction of a system of recording the sizes whenever these parts were dismantled. A copy of the form which has been used for recording this information is shown in Fig. 2. At first it was felt that these records would give us an indication of the direction of wear around the circumference of the cylinder and possibly lead to correction of it. However, there was found to be no regularity in this regard, some 60 per cent showing maximum wear at right angles to the crankshaft and the remainder lengthwise or at some intermediate angle. We have been unable, even by painstaking study of a great number of measurements, to associate this feature with any other detail of engine construction or performance. The principal value of this form has been in the determination of average rate of wear on cylinders of different groups of engines, thereby providing a basis for the maintenance program. The comparison of wear

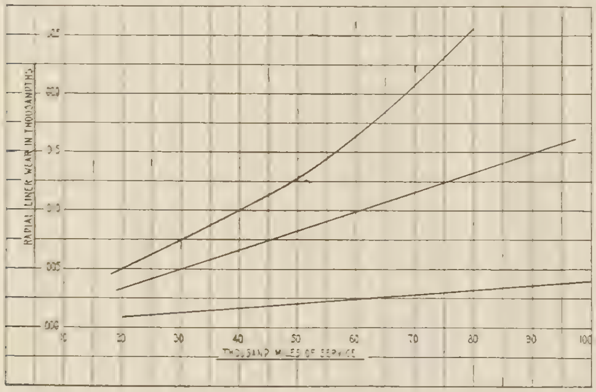


Fig. 4 Average Rate of Cylinder Wear in Rail-Car Engines

resulting from the use of different fuels and of different cylinder materials has also been gained from these records, and they have also shown the accuracy with which replacement cylinders are installed.

A typical example of the location of maximum wear is shown in Fig. 3. This picture is exaggerated to show the details of the worn portion. Although the wear is always greatest at top dead center, it is rather unusual for it to be almost entirely confined to such a short distance from top-ring travel. The wear at midstroke is always negligible and is only perceptible at bottom dead center on these engines.

What can be accomplished in reconditioning cylinders for further operation is, in the main, controlled by the number of engines involved. Several factors, however, must be given careful consideration, and too much emphasis cannot be placed on the value of accurate measurements of the wear occurring on both the pistons and cylinders. The analysis of these data permits important decisions to be made, such as: Whether reconditioning will be necessary and economical on both of these parts or if this attention can be confined principally to the cylinders. Where piston wear is relatively low, it is most economical to regain the original cylinder size by applying a bushing to existing cylinders as in locomotive service, thus avoiding any necessity for work on the pistons or supplying off-size rings.

Fig. 4, which was drawn from an inspection of a large number of forms such as shown in Fig. 2, shows the average rate of wear on the three groups of engines which we have in passenger service. An analysis of cylinder wear on individual engines produces a curve showing a gradual increase in wear up to 45,000 to 55,000 miles and then the wear is accelerated considerably. The shape of the top curve is more in line with the usual individual

TABLE 2 SIZES AND LETTER DESIGNATIONS FOR PISTONS AND CYLINDERS

Symbol	Size	Symbol	Size
A	0.075 in. oversize	*E*	0.025 in. undersize
B	0.050 in. oversize	*F*	0.050 in. undersize
C	0.025 in. oversize	*G*	0.075 in. undersize
D	Standard size	..	....

engine investigations. However, in plotting several hundred measurements, it is impossible to establish anything but a straight line as being the average rate of wear which can be expected. These curves are all the result of wear at top dead center on mild-steel cylinders which are fitted with aluminum pistons.

There are over 150 cylinders of similar type and size in service, which has permitted the establishment of sizes both above and below those which were set up by the manufacturers. It has been found that $^1/_{16}$ in. wear on diameter can be economically tolerated, giving due consideration to the increase in lubricating-oil consumption which results from wear on this part. In reconditioning, however, steps of 0.025 in. are desirable and economical in the reclaiming methods described later. It requires about 0.075 in. oversize to clean up properly a cylinder worn $^1/_{16}$ in. because of the wear being quite eccentric, or otherwise irregular, relative to the center line of the cylinder. In establishing these sizes it has been necessary, of course, to consider them in relation to similar steps on the pistons and the stocking of seven sizes of piston rings to suit. In the beginning, existing cylinders were bored out and oversize pistons applied. Later, as a result of an accumulation of worn standard-size pistons, undersizes down to 0.075 in. below standard were established. The symbols for size identification, which are stamped on both pistons and cylinders, are shown in Table 2.

Fig. 5 Worn Portion of Cylinder Repaired by Electric-Arc Welding

Fig. 6 Cylinder-Liner Chromium Plating on the Worn Portion Which Extends About 4 In. Down From the Top-Ring Travel

The arrangement does not require the previous size of the piston to be removed, but merely the addition of the new size. On cylinders, the sizes are stamped on the outside diameter of the collar which extends above the crankcase where it can be observed without removal of the head on most of the engines. The curvature of this surface permits easy removal of the previous size symbol when the cylinder is being rebored.

We are also reconditioning cylinders by depositing a band of metal on the worn portion for about 3 in. down from top dead-center position, with the electric arc. The cylinder is cleaned by grinding with a hand grinder to remove the surface metal and it is revolved during the welding process to keep distortion to a minimum. No attempt is made to regain the cylinder size by this method, but they are bored out about 0.015 in. above the original size and ground to 0.025 in. oversize. This means that a cylinder might be worn $^1/_{16}$ in., but be returned to service only 0.025 in. larger than previously. A section through the upper part of a cylinder which has been reconditioned in this manner is shown in Fig. 5. This enlarged section shows the typical porosity of the electric weld. The deposited metal, however, is considerably harder and more wear-resistant than the original cylinder material. The pores possibly are an advantage in regard to the retention of lubricant on this zone where the high temperatures often interfere with proper lubrication.

Fig. 6 shows a cylinder liner from one of the six-cylinder engines which was chromium plated at the worn portion for about 4 in. down from the top-ring travel. This was taken while the cylinder was being reground after plating. It had been worn about 0.024 in. on diameter and was plated sufficiently to bring it back to standard size and about 0.010 in. to clean it up. The vertical marks from the original use of this cylinder and the ring formed at bottom dead center are noticeable. A witness mark of the groove caused by maximum wear at the top is just in evidence and was removed during the finish-grinding. It is possible to set up these cylinders by the original surface and the measurements indicate that the cylinder is within 0.002 in. of the original size. The results of this application are not yet available. However, it will be watched with particular interest, inasmuch as it has to contend with elevated temperatures as well as abrasion. The fact that chromium is particularly resistant to chemical action of the fuel oil may also provide some data in connection with the "corrosion theory" which is being discussed so extensively.

FIG. 7 PITTING ON THE WATER SIDE OF A CYLINDER LINER

In addition to harder wearing surfaces resulting from the various reconditioning methods which have been used on mild- and tempered-steel cylinders, some very interesting information pertaining to the use of cast iron and nitrided steel for this purpose has been developed on these engines.

In the application of cast iron in place of steel, it has been necessary to reduce the cylinder size somewhat in order to provide sufficient strength, and this may have had an influence on the results. We have been unable to find a great difference in rate of wear on nickel iron, ordinary gray iron, or iron cast centrifugally. Any of them, however, appear to wear only about half as rapidly as mild steel. The greatest difficulty with the use of this metal on these particular engines, which were designed for steel cylinders, is in the application within the narrow confines of the crankcase.

Cylinders of nitralloy steel are giving a very creditable performance. Tests have been carried out over 259,000 miles in obtaining comparisons. These indicate that the maximum wear is 0.007 in. in 80,000 miles, which is only about one fourth to one fifth the amount on mild steel in similar service. The attempts which have been made to reclaim any cylinders of this material are unprofitable because of the difficulty in grinding the excessively hard surface. Also the second wear is inferior because the surface hardness is removed.

The pitting of the steel cylinders, as a result of the action of the cooling water on the outside, is also a problem which has been dealt with in maintenance. Fig. 7 shows an example of this condition. Zinc and aluminum spraying of some of the cylinders has been used to prevent this action in order to continue the cylinders in service for a longer period. A certain amount of pitting occurs at all times, but usually the cylinder is worn to the limits mentioned before serious weakness results. A limit of $^5/_{32}$ in. wall thickness, measured at the bottom of the deepest pit, has been set up for steel cylinders in order to avoid this condition. All liners are coated with a corrosion-resisting paint during manufacture or reconditioning to counteract the attack of the cooling water. No trouble whatever has been experienced with pitting on cast-iron or nitrided cylinders.

PISTONS

Of the various wearing parts of these engines, the pistons present the most complex problem, and have been the subject of considerable study both as to design and maintenance. The almost continuous variation in speed and load over wide ranges, which has to be dealt with in railway traction, makes greater demands on the piston than most services. Further, the introduction of aluminum-alloy pistons, so essential to these high-speed, lightweight engines has tended toward higher lubricating-oil consumption—first, because of the varying clearances between the piston and cylinder resulting from the previously mentioned service requirements; and, second, because the comparatively soft aluminum alloy wears more rapidly than other piston materials.

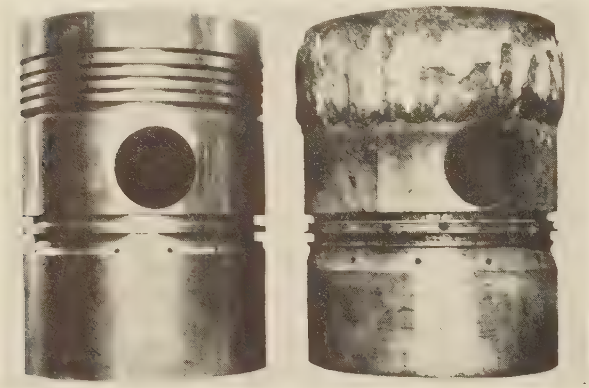
Considerable painstaking work and time have been necessary in developing maintenance methods to meet these conditions. However, a very satisfactory reduction in lubricating-oil consumption and reconditioning these parts has followed our efforts and we have been enjoying the benefits for several years.

Of the sand-cast, die-cast, and forged-aluminum pistons which have been employed since 1925, the forged metal is most suitable, as it is stronger, more ductile and wear-resistant. It is more expensive, however, because of the more costly process of manufacturing the metal and machining this part from the solid forging.

Wear of the ring grooves in any of the alloy pistons appeared as a difficulty early in the operation of these engines. It was, in fact, this item which determined their useful life. In bringing this factor within reasonable limits, it has been neccessary to consider the effect of the fuel oil as well as the design and metal from which the pistons are manufactured. In the early days, fuel specifications were written in broad terms to take care of the very wide territory in which these engines operated. However, it seems that two fuels can have apparently identical physical characteristics and yet the reaction on the piston from a wear standpoint may be widely different. Improved fuel specifications, which have been developed, and the adoption of narrower and diametrically thicker rings proved helpful. However, there was still the necessity for reconditioning the ring grooves. Wear on the top grooves has been limited to 0.006 in. and when this is exceeded the grooves are machined out to take overwidth rings. It has been proved that good piston rings in equally good grooves are steps in the right direction, and much of our effort has been directed toward this end.

Engines such as these, designed with minimum weight, of necessity have the wrist-pin hole somewhat above the center of the piston, which has a very limiting effect on the width of the lands between the piston rings. This restriction does not allow for much widening of the groove until the land is altogether too weak and subject to breakage. We have, therefore, limited this feature of our reclaiming operations to 0.025 in.

over standard width. The rate of wear on the ring lands remained so much greater than that occurring on the rubbing surfaces of the piston or wrist-pin hole that there are many pistons which could be used further provided the original condition could be regained at the ring belt. To accomplish this, acetylene welding is being employed and, in Fig. 8, at the right, is shown a piston which has had the entire ring belt machined off and new metal deposited by this method. At the left appears a similar piston after heat-treatment and machining. In the investigation prior to the adoption of this method, sand-cast and die-cast pistons were examined both before and after welding, and some of the results are shown in Fig. 9. This shows an enlarged section of an unwelded piston located in this work. This particular one is somewhat worse than average regarding porosity. Also in Fig. 10 is shown a section illustrating a welded piston, for comparison. This enlargement shows the condition of the welded ring belt after machining. It will be noted that the porosity even in the newly deposited lands is not



After Machining Before Machining

Fig. 8 Pistons Reclaimed by Acetylene Welding

nearly as serious as in the original casting shown in Fig. 9. The strength of original and welded lands on pistons was determined by the load required to break them off one at a time. Typical loads required to break lands off an original piston are 35,000, 36,000, and 35,500 lb while typical loads for a welded piston are 60,000, 66,000, and 64,500 lb.

It was thus observed that the deposited metal was considerably stronger than the original, and resulted in the employment of this method in lengthening the service of the pistons that were in good condition in other respects. Several trials were necessary to learn the proper heat-treatment for the various alloys, but, once this was understood, it was carried out in routine manner very successfully. Examination of the deposited metal indicated that it was not exactly the same as the piston material, although the welding rods were of similar composition before they were used. Apparently some change takes place during the process.

The file marks on the weld, shown in Fig. 8, are the result of taking samples for analysis. The machining of the outside diameters has been treated in line with that described for the cylinders. The welded pistons are always machined down 0.025 in. in diameter which removes any distortion caused during the welding process. The wrist-pin holes were found to close in slightly under this treatment and this is an advantage, since it permits the wrist pin to be refitted to standard clearances.

In connection with newly manufactured pistons of 8 to 12 in. diameter, it has been demonstrated repeatedly that a certain amount of distortion takes place soon after they are placed in service, and, in connection with reconditioned parts, this does not seem to be so noticeable. In the ordinary course of events, pistons which have been reconditioned after 75,000 miles have

Fig. 9 Microsection of Piston Before Welding

Fig. 10 Microsection of Piston After Welding

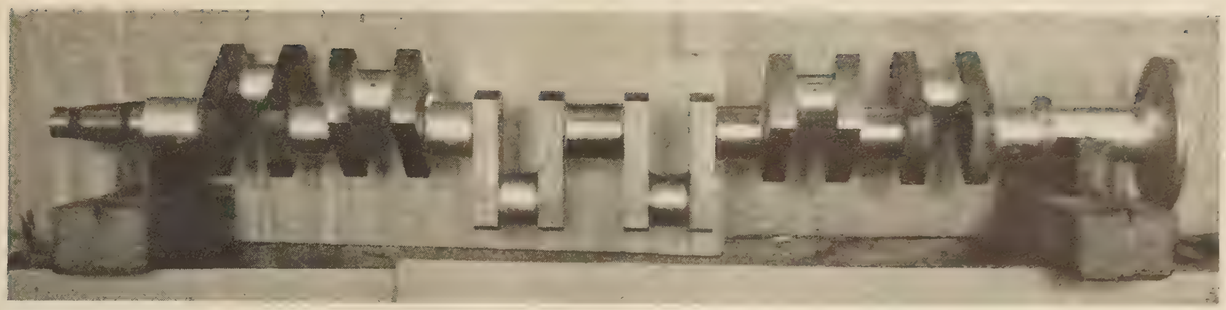


FIG. 12 CRANKSHAFT WITH MAIN AND CRANK BEARINGS CHROMIUM-PLATED

CANADIAN NATIONAL RAILWAYS

OIL ELECTRIC CARS

RECORD OF ENGINE SHAFT MEASUREMENTS

Car No. ..15629......
Eng. Type Beard. 6...
Eng. No. .114........
Date ..Jan. 20/31....
Miles ...199548......

		Diameter Journals		Difference		Diameter Crank Pins		Difference	
		F	R	V-H	F-R	F	R	V-H	F-R
1	V	4.996	4.994		.002	4.728	4.730		.002
	H	4.998	4.9965		.0015	4.728	4.730		.002
2	V	4.996	4.996		.000	4.729	4.732		.003
	H	4.995	4.9955		.0005	4.730	4.7315		.0015
3	V	4.995	4.995		.000	4.727	4.731		.004
	H	4.9955	4.9955		.000	4.7275	4.732		.0045
4	V	4.994	4.9925		.0015	4.7325	4.7345		.002
	H	4.9935	4.9935		.000	4.7335	4.7355		.002
5	V	4.994	4.9945		.0005	4.729	4.732		.003
	H	4.995	4.996		.001	4.7305	4.7315		.001
6	V	4.996	4.997		.001	4.7315	4.7325		.001
	H	4.996	4.9965		.0005	4.7325	4.7335		.001
7	V	4.995	4.996		.001				
	H	4.9965	4.9975		.001				
8	V	4.995	4.9955		.0005				
	H	4.9965	4.997		.0005				
9	V								
	H								

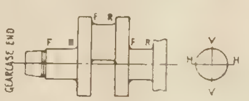
NOTES

F = Front nearest to gear case
R = Rear
V = In vertical plane
H = In horizontal plane
Difference between V and H indicates ovality and should be zero.
Difference between F and R indicates taper and should not exceed .002 in.

When being measured the crankpin to be on T.D.C.

If serious ovality is found on main journals, the measurements shall be recorded in relation to a T.D.C.

Recorded at: Winnipeg, Man.
Recorded by: Geo. F. Shaw



REMARKS.

Shaft No. 33263 N 1097
(Nickel Chrome)

CANADIAN NATIONAL RAILWAYS
OFFICE OF CHIEF ELECT. ENGR.
MONTREAL, January 30, 1931.

FIG. 11 FORM FOR RECORDING RATE OF CRANKSHAFT WEAR

been fitted with smaller clearances without any evidence of seizure.

CRANKSHAFTS

Diesel-engine crankshafts are handled in a manner similar to the pistons and liners in regard to records of wear and sizes. In Fig. 11 is shown a copy of this form which is typical of the wear occurring on this part. In some studies made several years ago comparisons were made between nickel, chrome-nickel, and carbon steels for wear resistance, and it was found that there was very little choice between them. However, in replacement, the trend has been toward alloy steels because of the harder bearing surfaces and greater strength. On main journals, the wear varies between one and two thousandths on diameter in 100,000 miles and the crankpins show six to nine thousandths during this period on the usual run of crankshaft steel.

The Nitralloy crankshafts which were applied several years ago are standing up remarkably well, and, on the average, indicate the wear to be about one sixth that usually found. In practically every instance, regardless of the type of steel, however, the crankpin wear is four to five times that found on the main journals. In reconditioning crankshafts the practice is to turn the crankpin and journal which is in the worst condition first, and then use the size which has been thus established for the remaining pins and journals. In this way it is not found necessary to establish definite undersizes for this part, and in a measure this has extended the life of the shafts, as only sufficient metal is removed to true them up. Very good results have been obtained with a Webber tool in turning crankpins. This tool is one of the type which is used in the lathe and follows the crankpin around in its normal path when revolving on the main journal centers. Any pins which are oval are first filed to make them round so that the tool will be guided by a fairly true surface throughout the entire operation. Wooden polishing blocks are employed and fine abrasive compounds are used in the final finishing, producing accuracy in line with manufacturers' tolerances.

A crankshaft from one of the six-cylinder engines, which is about 9 ft long, is shown in Fig. 12. This has the main journals and crankpins chromium-plated with the object of lowering the rate of wear. The sizes were increased 0.010 in. which, although not regaining the original size, is thought to be sufficient to prolong the life of the shaft for a considerable period. The tolerance of the plate itself was kept within one-half thousandth, which is very creditable for such a large article. There has not been sufficient service on this shaft as yet to indicate any wear. However, as the hardness is in line with nitriding, it is expected that the rate of wear will be very low.

CONNECTING-ROD CRANK BEARINGS

One of the problems which developed in the early use of these engines, and for which the maintenance staff was obliged to find a solution, related to crank-bearing failures. This amounted to cracking of the babbitt lining in the rod or top half of the bearing which continued until most of the babbitt in the high-pressure area was loose and broken in small pieces. If this condition was not detected, the detached pieces pounded out until they interfered with lubrication, causing heating, or the bearing shell came down on the crankpin. It was found that it did not take long for most of the babbitt to become loose after the initial crack had formed and it was not unusual for loose babbitt to go unnoticed until the bearing was removed for inspection. The loose pieces would, of course, fall out when the bearing was disturbed, and renewal was necessary. Cracking never occurred in the bottom half of the bearing and the main bearings also were practically trouble free. The fact that the babbitt metal employed included all the popular tin-base alloys and from failures which occurred with several of these which were applied under expert supervision, there was a strong belief that

the loads were too high. To offset this, however, a study of the records indicated that some bearings operated in excess of 200,000 miles without renewal. These, of course, were rather exceptional in the early days. However, these rare occurrences indicated the direction of improvement, and final solution of the problem followed.

Flexing of the bottom end of the connecting rods was given attention and, in later installations, bearing sizes were increased and the rods strengthened. An idea of the extent of this alteration can be gained from Fig. 13 which indicates the differences in weight. However, the trouble continued and, at one stage

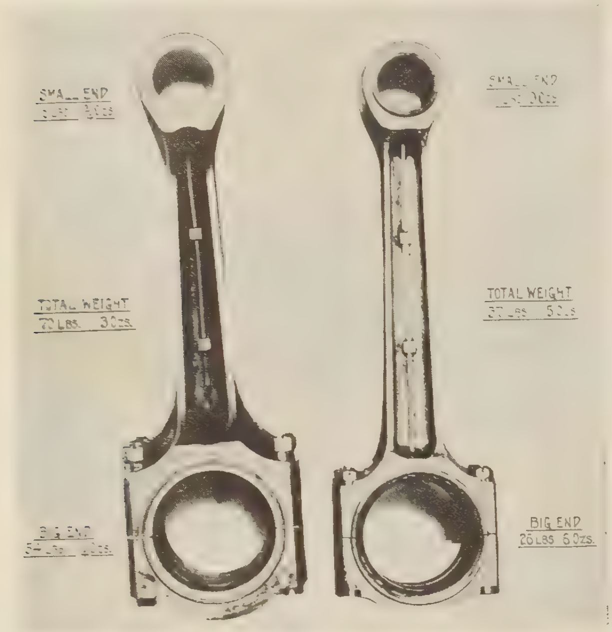


Fig. 13 Comparison of Connecting Rods Before and After Increasing Strength and Bearing Sizes

of the investigation, several methods of babbitting the crank bearings were tried. These included babbitting direct on the steel rods without the use of shells, and the use of bronze-lead combinations which were only partially successful. The experience which was gained resulted in some very definite ideas regarding the best type of crank bearing for railway traction.

Protection of the crankshaft against damage under severe and abusive conditions is an important factor because passenger trains must be on time if humanly possible. This means that under abnormal conditions an engine may be operated without a proper supply of lubricating oil, with disastrous results. The development of a crank-bearing shell which can be operated after the babbitt has disappeared without damaging the shaft is the answer. The use of a shell of this type which can be easily removed for inspection or replacement, has permitted reasonable maintenance and provided good protection for the crankshaft.

As a consequence of the poor results obtained with the bearings in the early days and the time required to obtain replacements and deliver them to remote parts of the railway system, attempts were made to manufacture bearings in the railway shops. At first these were not very successful, but by the use of special babbitt with high lead content, together with improved practice regarding its application, the crank bearings have ceased to be a troublesome feature in maintenance. Lead is usually thought of as an extremely soft and ductile metal. However, the addition

TABLE 3 ANALYSIS OF BEARING MATERIAL

Element	Babbitt, per cent	Lead-bronze, per cent
Copper	1.00	77
Lead	78.75	15
Tin	1.25	8
Antimony	18.00	
Arsenic	1.00	

of antimony and arsenic gives it a surprising hardness without interfering with its antifriction qualities.

Bronze shells with a phosphorus content were also found to be unsuitable and the best results are being obtained with babbitt, and shells of the composition given in Table 3. The jig which is employed is made solid in order to retain the heat and it is kept between temperatures of 250 and 300 F. The tinning bath is composed of babbitt containing 70 per cent tin and 30 per cent lead solder, maintained between temperatures of 600 and 650 F. Considerable care is exercised in maintaining the babbitt pot at 1050 F, and the molten metal is poured from a ladle previously raised to the same temperature. This ladle is of a large size enabling a complete pour to be made in one operation. The shell is not removed from the jig until it has cooled to 225 F.

During the tinning process the shell is completely immersed in the bath and left until it has reached a uniform temperature, being removed to coat it with soldering flux. This, briefly, is

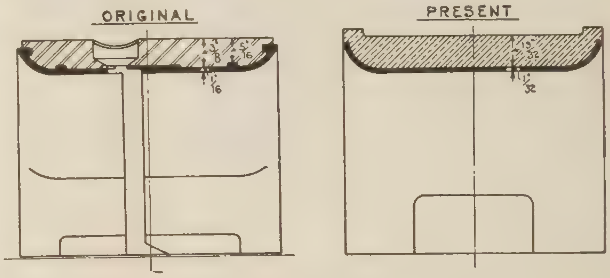


Fig. 14 Changes in Design of Connecting-Rod Crank Bearings Which Has Increased the Service Life of the Bearings

Diameter of crankpin, in.	4.75
Original effective length of crankpin, in.	2.043
Original projected area of connecting-rod crank bearing, sq in.	9.7
Pressure, lb per sq in., gas load only	4400
Pressure, lb per sq in., gas inertia	3560
Rubbing speed, fps	16.5
Number of bolts in crank end of connecting rod	2
Capacity of lubricating-oil pump at 800 rpm, gpm	34.1
Number of cylinders	6
Engine speed, rpm	800

the practice employed during the process and great care is exercised to insure cleanliness and accuracy.

The rough hammer-and-chisel maintenance methods credited to the railway organization no doubt caused unnecessary failures, but this same method applied to the babbitt of the big-end bearing resulted in a test definitely proving the degree of adherence between the babbitt and shell. When this chipping test showed that there was no tendency for the babbitt to peel away from the shell, an almost perfect bond existed between the two metals. The feature since that time has been only the reproduction of the conditions under which this satisfactory bonding occurred, and in this respect the human element plays an important part. There is now only an occasional bearing which shows trouble on inspection, and the average life of these is well above 100,000 miles. Most of the engines go from shopping to shopping without renewal.

In the manufacture of bearings, certain slight changes were found beneficial. These are illustrated in Fig. 14 and show the details of a bearing which was one of the worst offenders, together with particulars of the working conditions. Fig. 14

TABLE 4 MAINTENANCE PRACTICE FOR DIESEL-ENGINE PARTS

Part	Limits of wear	Average mileage	Type of repairs
Crankshaft	0.006 in. out-of-round on two or more crankpins	250,000	Recondition
Cylinders	Worn between 0.045 and 0.060 in. on diameter	150,000	Recondition
Pistons	Worn 0.010 in. above top ring; 0.006 in. clearance in three ring grooves; 0.005 in. clearance in wrist-pin hole	100,000	Recondition
Connecting-rod bearings	Clearance maintained between 0.003 in. and 0.004i n. by adjustment of shims	No record of worn-out bearings	
Wrist pins	Worn 0.006 in. on diameter	300,000	Renew
Exhaust valve	Renew when bent, warped, or stem worn 0.005 in.	75,000 200,000	Grind Renew
Exhaust-valve guide	Renew when worn 0.008 in.	100,000	Renew
Piston rings	Gap opening increased to $^1/_8$ in.	75,000	Renew

shows the original design and the improvement which has been in successful operation for several years. Anchor grooves and oil grooves were eliminated and the babbitt thickness has been materially reduced. Oil pockets were cut at right angles to the rod center line and end collars have been added.

Bearings of $4^3/_4$ to 5 in. diameter are installed with only 0.001 to 0.002 in. clearance, and operate at normal temperatures with clearances of 0.003 in.

General

A certain amount of distortion is found in the main-bearing openings of the crankcases after several years of service. However, the practice of line reaming the main bearings in place which has been adopted, takes care of this. The slight differences in babbitt thickness which results from this practice is of no consequence. The same type of bearing is used in the mains as in the connecting rods previously described. Extremely long life is obtained from these. However, in the ordinary course of events they are renewed at each general overhaul when the crankshaft is reconditioned. In other words, these bearings do not wear out but are replaced with bearings of smaller size to accommodate the reconditioned shaft.

The reconditioning of aluminum cylinder heads with steel valve seats has presented no problems uncommon to automobile engines. Occasionally a head will become cracked and, excepting when this occurs in the combustion-pressure area, it is repaired by welding. A 50-lb hydraulic test of the water space is made following such repairs. Reaming of the seats is required at periods of 100,000 miles. Exhaust-valve guides also require renewal at this period.

The four-cylinder engines have been practically free from any renewal of parts in the gear cases in spite of mileages around 500,000. On the six-cylinder engines, however, this unit becomes noisy at about 150,000 miles and will require renewal of gear-case parts at 200,000 miles. It is likely that the difference in torsional vibration is responsible for this, and on some occasions it has been noted that early trouble with the gears was associated with an improperly adjusted vibration damper.

The type of wrist pin with which these engines are fitted, which is free to revolve both in the piston and the bearing, is very easy to maintain. It is only in the last few years that they have required any attention. Wear of 0.006 in. is the maximum which has been found even after many years operation. This is rather surprising as the loads on this part are high. The wear on wrist-pin bosses in the piston and also in the rod bushing is relatively low, and the only measure which has been taken to regain the original clearances on worn parts is in providing 0.005 in. oversize pins by means of chromium plating.

Fuel-injection pumps and atomizers are sent in to a central repair shop which is adjacent to a toolroom equipped to make adequate repairs. Plungers and valves are reduced in diameter 0.003 and 0.005 in. as required, and new bushings are fitted. Considerable technique has been developed in this work, and lapping of the parts which at one time was a tedious job has been cut to a minimum. Each pump unit is given a static test of 5000 lb pressure as an initial check for leakage. The completed pump is put on an operating test and the fuel quantities balanced using the atomizers which are to be installed with it.

Governors, lubricating-oil pumps, water pumps, and primary fuel-oil pumps operate over 200,000 miles between shopping

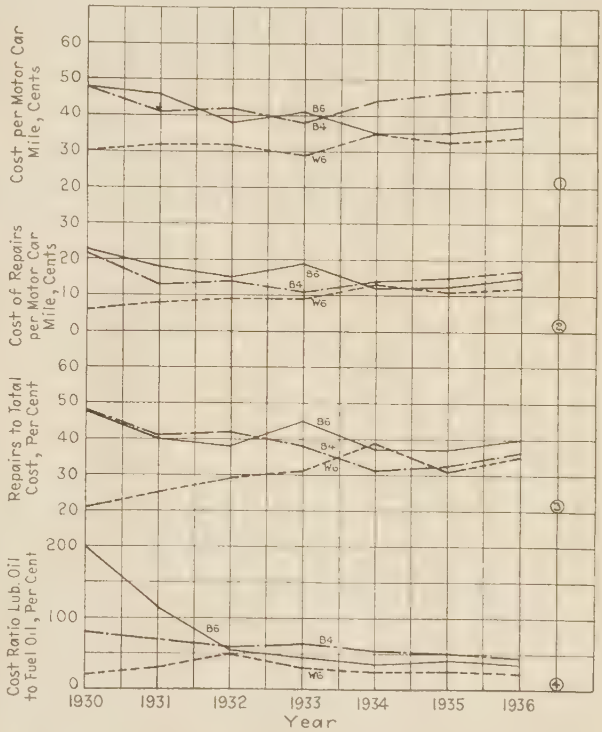


FIG. 15 COST PER CAR MILE FOR DIESEL-ENGINE OPERATION

AVERAGE DAILY MILES PER ENGINE

Year	Miles	Year	Miles
1929	220	1933	185
1930	206	1934	184
1931	191	1935	191
1932	180	1936	181

periods without trouble. Often these will go to the third general overhaul before requiring much attention. Two or three spare units of each type have been provided for protection and are handled similarly to pistons and liners, being repaired at a central shop and sent to outlying repair points as occasion demands.

Some further impressions of the average mileage which is being obtained from various engine parts under the maintenance practices which have been described are shown in Table 4. This also shows data relating to the limits of wear which are in effect.

Further details of the more important factors pertaining to the cost of maintenance are included in Fig. 15 for years 1930–1936. The average trend of total cost per mile, shown in curve 1, has been downward to 1934 and has held between 36 and 40 cents per mile since then. One of the greatest influences on total cost is total miles and, unfortunately, as a result of alterations in train schedules, the runs which have been operated by this equipment are shorter than previously. At one time groups of these cars were on runs of 300 miles per day and this dropped to

220 miles in 1929 and has made a further drop of 13 per cent since. The fact that repair cost has held constant, or been slightly lowered, as shown in curve 2, in spite of this, is very gratifying. It has been impossible to obtain the cost of engine repairs separate from the other mechanical and electrical repairs. However, the fact that there has been a general improvement in this is seen from curve 3, which gives the repairs in per cent of total cost. Last, but not least, in curve 4 is shown the very satisfactory reduction in lubricating-oil consumption which has resulted from a systematic handling of pistons and cylinder-liner repairs.

Some ideas on depreciation of Diesel-engine equipment can be gained from our experience. In the first place the results after 12 years with the oldest engines indicate that an estimated life of 20 years is conservative. The possibility of engines of this type becoming obsolete or the costs rising to where they are uneconomical after extended service is remote. By inexpensive investigation, it is possible during overhaul to improve and modernize the engines, even within the narrow confines of existing crankcases, with beneficial results. Finally, by careful records of wear being kept, a systematic handling of repairs can be set up which results in a lowering and stabilizing of engine-repair costs. Up to the present it would appear that depreciation is practically taken care of by renewal of the active parts.

Resistance of Lightweight Passenger Trains

By A. I. TOTTEN,[1] ERIE, PA.

The author discusses the factors affecting the resistance of modern lightweight streamlined trains, using the fundamental data collected by different authors, and presents them in a more practical form than heretofore available. These factors include those due to track and journal resistance, flange resistance, and air resistance, as well as the resistance offered by natural or ground winds and by the installation of air-conditioning and lighting equipment on the cars. The author gives formulas for calculating such resistances, and includes in the paper examples showing how to apply the formulas.

FOR MANY years there was little information available in a concrete form, for the guidance of transportation engineers, in the matter of tractive resistance of locomotives and cars of various types and weights. Antedating that time, however, Schmidt and Dunn[2] at the University of Illinois, the Pennsylvania Railroad, and the General Electric Company had obtained considerable experimental data which were directly applicable only to certain specific conditions.

About ten years ago W. J. Davis, an engineer of the General Electric Company, correlated the various sources of information and issued a treatise[3] which subsequently became, throughout the world, the recognized authority on this most important subject. Although Davis' formulas related specifically to electric locomotives, nevertheless they are susceptible of application to steam engines by segregating the losses peculiar to this type of motive power.

Recent years have produced rolling-stock developments, especially in the case of passenger equipment, which, although in some measure visualized by Davis, were not embraced in the formulas and curves, which covered in detail practically all forms of the then existent motive power and cars.

[1] Transportation Department, General Electric Company. Mr. Totten began his railroad career in 1900 with the Southern Railway. He was then appointed electrical engineer of the Queen and Crescent Railway at Cincinnati, Ohio, and later became engineer of shops for the Southern Railway, and then electrical engineer for the Seaboard Air Line Railway. After leaving this position he spent several year with the General Electric Company in the study of the requirements of shop equipment of the various steam railroads. He then accepted a position as electrical engineer and assistant superintendent of motive power with the Brazil Railway, with headquarters at Sao Paulo, Brazil. Returning to the United States as expert appraiser of special railroad franchises for the New York State Tax Commission, he rejoined the General Electric Company in 1918. Since that time he has made exhaustive studies connected with the application of electric power and Diesel-electric equipment to steam-railroad operation. He is a member of the American Institute of Electrical Engineers, and has contributed numerous papers and articles to the technical press.

[2] "Passenger-Train Resistance," by E. C. Schmidt and H. H. Dunn, Engineering Experiment Station, Bulletin No. 110, University of Illinois, Urbana, Ill.

[3] "The Traction Resistance of Electric Locomotives and Cars," by W. J. Davis, Jr., *General Electric Review*, October, 1926, pp. 685–707.

Contributed by the Railroad Division for presentation at the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until July 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Rapid progress along the lines of lightweight, streamlined, and articulated equipment, appears to make essential the derivation of new methods of approach for the determination of tractive resistance factors, upon which must be based all calculations pertaining to train time schedules, power-plant capacity and fuel consumption for modern railroad service.

It is the intention of the author to draw freely from Davis' valuable contributions[3] on the general subject and also from the paper by DeBell and Lipetz[4] which deals specifically with air-resistance components. As a matter of fact, it is not the intent to introduce any new fundamental data in this paper, but to merely condense into more practical form, for universal application, the researches of other engineers along the lines in question.

There appears to be no reason for departing from Davis' original segregation of train-resistance factors, which may be summarized as follows:

(*a*) Those that are constant with respect to speed, R_1.
(*b*) Those that vary as the first power of the speed, R_2.
(*c*) Those that vary as the square of the speed, R_3.

For convenience in discussion, these three factors will be separately treated under the following subjects.

Track and Journal Resistance

According to the Davis formulas, these elements are covered by a fixed and a variable component, the latter being inversely affected by individual axle loadings. Based upon Schmidt's[2] experiments these factors were expressed as

$$\text{Unit resistance per ton} = 1.5 + (100/W)$$

where W represents the entire weight in tons on four axles. The modification in the Davis formulas shows

$$\text{Unit resistance per ton} = 1.3 + (29/w)$$

where w represents the weight per axle in tons. The differential, as between these authorities, results in the following:

$$\text{60-ton car}\begin{cases}\text{Schmidt } 1.5 + \dfrac{100}{60} = 3.17 \text{ lb per ton}\\[2ex] \text{Davis } \quad 1.3 + \dfrac{29}{15} = 3.23 \text{ lb per ton}\end{cases}$$

$$\text{30-ton car}\begin{cases}\text{Schmidt } 1.5 + \dfrac{100}{30} = 4.83 \text{ lb per ton}\\[2ex] \text{Davis } \quad 1.3 + \dfrac{29}{7.5} = 5.17 \text{ lb per ton}\end{cases}$$

Thus, the unit resistance, as between the two formulas shows decreases of the order of 34.5 to 37.5 per cent for an increase in the car weight of 100 per cent.

Apparently no attempt has been made to segregate the components of rolling resistance, track resistance, and journal friction, although it would appear that the value of journal friction might be established independently of the other elements, through the medium of stand tests. Furthermore, it seems, that while the unit of journal resistance will vary more or less inversely with

[4] "Air-Resistance of Passenger Trains," by G. W. DeBell and A. I. Lipetz, *Railway Mechanical Engineer*, vol. 109, December, 1935, pp. 496–501.

the weight per axle, the rolling resistance, for a given rail weight, will vary to some extent directly with the axle loading.

The tendency is ever prevalent toward larger rail sections, and the lightweight equipment, now under discussion, has materially lower axle loadings and consequently wheel pressures. Both of these elements act in the same direction, pointing to a decrease in track resistance occasioned by the so-called "wave action." This feature is emphasized in tests on the Kansas City Southern Railway,[5] conducted in 1930, which showed a reduction of 0.4 lb per ton with identical axle loadings, but with the rail weight increased from 84 to 150 lb per yard.

These mentioned tests[5] indicate a resistance decrease of 0.1 lb per ton for a rail-weight increase of 19.7 per cent, consequently it may be reasonably assumed, that a corresponding reduction in axle loading, with a constant rail weight, will produce similar results.

The tendency in lightweight equipment indicates a reduction in unit axle loading of about 17 per cent for locomotives and from 12 to 25 per cent for cars to operate on existing tracks. While it would therefore seem proper to make some reduction in the first group of the Davis formulas for the reasons herein cited, it is not believed that the information at hand is sufficiently conclusive to warrant such action.

The advent of roller journal bearings on rolling stock does not appear to have a material effect on the resistance units involved, although it is fully recognized that the initial starting resistance is thereby reduced materially as compared to A. A. R. brass journal bearings. Some opinions and tests controvert this statement.

One roller-bearing company presents laboratory tests, which show a decided uniformity of resistance for roller bearings, which is irrespective of speed and with values of one third to one sixth of those applying to journal brasses.

Another roller-bearing manufacturer estimates a decrease in resistance for roller bearings of 80 per cent at starting, 25 per cent at 15 mph, and 33 per cent at 75 mph, as compared to journal brasses.

Certain tests, made by the Chicago, Milwaukee, St. Paul, and Pacific Railroad indicated an overall differential of 0.6 lb per ton in favor of roller bearings for 80-ton six-axle cars at a speed of 10 mph. This constitutes a decrease of 17 per cent from the components normally applied, under like conditions, to brass journal bearings.

The Budd Manufacturing Company estimates a reduction of 20 per cent in journal friction for roller bearings, presumably under high-speed operating conditions.

The experience of other manufacturers, which is supported by Pennsylvania Railroad and Illinois Central Railroad tests, does not indicate, that at normal operating speeds, there is any pronounced difference in resistance values for the two classes of bearings under discussion.

After giving due consideration to all of the foregoing and pending more definite information on the subject, it is decided to maintain the Davis factor as uniformly applicable to both roller bearings and journal brasses. The final components for R_1 thus become

$$R_1 = 1.3 + \frac{29}{w} \quad [1]$$

where w = weight per axle in tons.

Flange Resistance

The term "flange resistance" shall include all forms of resistance proportional to the first power of the speed. These also embrace, in general, flange friction, resistance elements due to concussion, swaying, and oscillation. It is obvious, that the character of track construction, truck-wheel spacing, the use of truck restraining devices, and other items of lesser import are controlling factors in the constant to be employed.

In Davis' analysis of this problem there are established constant values varying from 0.03 to 0.09 depending upon the type of service considered. These constants are as follows:

Locomotives (electric)	0.030
Passenger cars (4 or 6 axle)	0.030
Freight cars (4 or 6 axle)	0.045
Multiple-unit cars (4 axle)	0.045
Interurban cars (operated singly)	0.090

The high value of 0.09 was used only for single car operation, where oscillations, etc., are naturally magnified without the restraining influence exercised by a connected train.

The lightweight high-speed equipment considered in this analysis will consist of locomotives or power units weighing from 75 to 250 tons in combination with lightweight four-axle or articulated cars.

There is no question but that the locomotives or power units should be placed in the category where the 0.03 constant applies. The relatively lightweight trailing cars will have comparatively short truck-axle centers. As an offsetting feature, however, the highest grade type of construction, probably with truck-stabilizing features, is employed. In addition, high-speed operation is of necessity conducted over a well-maintained right of way, with the resultant oscillating features held to a minimum. Furthermore, the recent practice of flat turning the tire treads gives every indication of materially reducing flange contact and pressure on the rail head when operating on tangent track.

For all of the reasons cited in the foregoing paragraph, it is decided to maintain the present minimum factor for both locomotives or power units and the trailing cars. The constant therefore remains as

$$R_2 = 0.03\,V \quad [2]$$

where V = speed, mph.

Air Resistance

Air resistance, in effect, covers not only head-end resistance but all air elements, including those pertaining to such factors as turbulent or eddy currents, skin friction, ground wind, and viscous drag. It is generally assumed that such resistance varies as the square of the speed which, while not entirely true, is sufficiently accurate for all practical purposes.

The Davis formulas apparently took cognizance of the fact that a more or less definite relationship existed between the cross section, weight, and length of the individual car units, which accorded automatic compensation for skin effects. Thus, he used the head-end area in combination with a proper constant for establishing total air resistance and divided the resultant, so derived, by the weight of each individual car or locomotive for the purpose of obtaining the unit resistance expressed as pounds per ton.

The later use of aluminum and high-tensile steel alloys, disturbed the previously mentioned equilibrium so that the principal authorities on this particular subject now deem it best to take the cross-sectional area or perimeter of the locomotives or cars, in combination with the length, for securing total air-resistance values.

Streamline effects were considered by Davis,[3] but not extended to the formulas or curves in which his studies culminated. Based upon tests made in St. Louis by the Electric Railway Test Commission, he established the following coefficient per-

[5] "What is the Economic Weight of Rail," *Railway Age*, vol. 88, May 24, 1930, pp. 1231–1237.

centages for the body only, with different forms of vestibule constructions, which presumably applied to both ends of the individual car as tested. These are as follows:

Flat	100 per cent
Standard (truncated wedge)	67 per cent
Parabolic	35 per cent
Parabolic wedge	33 per cent

It was ascertained that the single car, used in the previously mentioned St. Louis tests, produced a coefficient of air resistance of 0.00228, which was magnified to 0.0024 in the Davis formulas. If the ends of the car had been of parabolic shape, but without other changes, then the coefficient as applied to the head-end cross-section and the V^2, would become 0.001495.

In recent years, through the medium of wind-tunnel tests, considerable data have been collected, especially for airplanes and streamline-train resistances which are of value in the determination of R_3 or the third factor of the train-resistance formula. This whole subject is well presented by DeBell and A. Lipetz,[4] and by Ober.[6]

It is obvious, that the selected shape of the head and rear end of the train, as well as many other details of design, which may be influenced by factors other than those attributable solely to air-resistance features, will have some effect on the final resistance units that will apply. These variables are represented by the symbol K in formulas to follow. Open-skirt construction (18 in. from skirt to top of rail) or closed-skirt construction, where the entire underframing is shrouded, are elements which must also be considered. The relative constants for these last two alternative methods of construction on power cars, as defined by DeBell and Lipetz,[4] is 0.00224 for open skirts, 0.002 for closed skirts; the decrease for closed skirts is therefore 0.00024 or 10.75 per cent.

The K factors, as ascertained from the tests, are as follows:

K_1 = For power or leading-car nose well streamlined = 0
For nose bluntly streamlined = 0.000036 × cross-sectional area of nose at full section, including trucks, in square feet

K_2 = For tail shape of rear car well streamlined = 0
For tail bluntly streamlined = 0.000061 × cross-sectional area of tail at full section, including trucks, in square feet

K_3 = For power-car trucks, both faired = 0
For unfaired trucks = 0.00026

K_4 = For faired trailing-car trucks = 0
For unfaired trucks = 0.00013 × number of trailing-car trucks

K_5 = For smooth diaphragms = 0
For cowled diaphragms = 0.000037 × P_c × number of diaphragms

K_6 = For no bulge of power car = 0
For bulge of good streamline shape = 0.00032 × cross-sectional area of bulge in square feet
For bulge of relatively poor streamline shape = 0.00051 × cross-sectional area of bulge in square feet

K_7 = For closed wheel shrouds on streamlined locomotives (all wheels completely enclosed) = 0
For open shrouds (2 ft × 2 ft 6 in. inspection openings over the driving-wheel journals) = 0.0005 × total number of openings
For short shrouds (driving wheels and tender trucks completely exposed) = 0.0182

K_8 = For helmet nose on streamlined locomotive = 0
For straight nose = 0.0021
For round nose = 0.0026

K_9 = For round-top boiler shape on streamlined locomotive = 0.
For cowled top (domes and fittings enclosed in longitudinal cowl above boiler shroud) = 0.0035

For the purpose of this analysis and in order to present some examples showing the adaptation of the DeBell and Lipetz[4] formulas, the following three basic types of equipment are selected:

1 The streamlined locomotive-hauled train with open-skirt streamlined cars, having (*a*) no adverse design elements and (*b*) maximum adverse design elements.

2 The streamlined locomotive-hauled train with standard cars, having (*a*) no adverse locomotive-design elements and (*b*) maximum adverse locomotive-design elements.

3 The streamlined power-unit articulated train with closed skirts, having (*a*) no adverse design elements and (*b*) maximum adverse design elements.

For the first case, a streamlined electric, Diesel-electric, or steam locomotive with a train of lightweight streamlined cars is assumed. The simplified formula, as established by DeBell and Lipetz,[4] is

$$R_3 = (0.023\sqrt[3]{L_L} + K_L) + \left[0.001735P_c\left(\frac{L_c}{100}\right)^{0.88} + K_c\right]V^2 \qquad \text{[3]}$$

where L = length of train, ft; L_L = length of locomotive or locomotive and tender, ft; L_c = length of car consist (rear of locomotive or tender to rear of train), ft; P_c = perimeter of cars from plane of top of rails over car to plane of top of rails, ft; and K_L and K_c = constants based upon details of construction.

The constants for the locomotive resistance presuppose a cross-sectional area equivalent to that of the New York Central Hudson-type steam locomotive which is a fair average for all locomotives considered for the particular type of service now analyzed. The individual formula for the locomotive, reduced to a unit basis, expressed in pounds per ton is

$$R_3 = \frac{(0.023\sqrt[3]{L_L} + K_L)V^2}{W} \qquad \text{[4]}$$

and for the cars (14 ft high from top of rail to roof, 10 ft wide, and with an effective perimeter of 40 ft), expressed in pounds per ton is

$$R_3 = \frac{\left[0.0694 \times \left(\frac{L_c}{100}\right)^{0.88} + K\right]V^2}{W} \qquad \text{[5]}$$

where W = total weight of locomotive or cars, tons.

For the second case a streamlined electric, Diesel-electric or steam locomotive with a train of standard vestibuled cars is assumed. The simplified formula is

$$R_3 = (0.023\sqrt[3]{L_L} + K_L) + \left[0.0031 \times P_c\left(\frac{L_c}{100}\right)^{0.7} + K_c\right]V^2 \qquad \text{[6]}$$

The locomotive formula for unit resistance remains as in the first case, that is, Equation [5].

The following substitution, expressed in pounds per ton applies to the cars

$$R_3 = \frac{\left[0.124\left(\frac{L_c}{100}\right)^{0.7} + K\right]V^2}{W} \qquad \text{[7]}$$

---

[6] "Air Resistance of the Burlington 'Zephyr,'" by S. Ober, *Railway Gazette*, Supplement, June 14, 1935, p. 1184.

For case No. 3, the train hauled with a power unit is treated as a whole upon the basis of the formula

$$R_3 \left[0.0020\, P_c \left(\frac{L}{100}\right)^{0.8} + K \right] V^2 \ldots\ldots\ldots\ldots [8]$$

The cross-section areas for trains of this character are somewhat less than that for the locomotive-hauled trains previously considered. The distance from top of rail to roof is now taken as 12 ft and the width as $9^1/_2$ ft, thus producing a perimeter of 35 ft. On this basis the unit formula expressed in pounds per ton, may be simplified somewhat as

$$R_3 = \frac{\left[0.07 \left(\frac{L}{100}\right)^{0.8} + K \right] V^2}{W} \ldots\ldots\ldots\ldots [9]$$

The application of the suggested formulas to hypothetical train compositions is shown as follows, based upon certain assumptions, as defined along the lines of recent developments.

Example—Case No. 1

Consider a locomotive with a weight of 200 tons, a length of 80 ft, and eight axles. The train consists of ten 50-ton, 70-ft cars with four axles per car, assume a train speed of 90 mph.

Ideal Design. The resistance of the locomotive is

$$R = 1.30 + \frac{29}{w} + 0.03\, V + \frac{(0.023\, \sqrt[3]{L_L} + K)V^2}{W}$$

$$= 1.30 + 1.16 + 2.70 + \frac{(0.023 \times 4.3 \times 8100)}{200}$$

$$= 9.17 \text{ lb per ton}$$

The resistance of the cars is

$$R = 1.30 + \frac{29}{w} + 0.03\, V + \frac{\left[0.0694 \left(\frac{L_c}{100}\right)^{0.88} + K \right] V^2}{W}$$

$$= 1.30 + 2.32 + 2.70 + \frac{(0.0694 \times 5.54 \times 8100)}{500}$$

$$= 12.55 \text{ lb per ton}$$

The resistance for the locomotive and cars is

$$R = \frac{(9.17 \times 200) + (12.55 \times 500)}{700}$$

$$= 11.58 \text{ lb per ton}$$

The horsepower output at the wheels for balanced speed on level tangent track is

$$\frac{11.58 \times 700 \times 90}{375} = 1945 \text{ hp}$$

Adverse Design. The resistance of the locomotive is

$$R = 1.30 + 1.16 + 2.70 + \frac{(0.023 \times 4.3 + 0.0243)8100}{200}$$

$$= 10.16 \text{ lb per ton}$$

For the cars

$$R = 1.30 + 2.32 + 2.70 + \frac{(0.0694 \times 5.54 + 0.015)8100}{500}$$

$$= 12.79 \text{ lb per ton}$$

For the locomotive and cars

$$R = \frac{(10.16 \times 200) + (12.79 \times 500)}{700}$$

$$= 12.05 \text{ lb per ton}$$

The horsepower is

$$\frac{12.05 \times 700 \times 90}{375} = 2024 \text{ hp}$$

Example—Case No. 2

The conditions for this case are the same as for case No. 1, except with standard vestibuled 70-ft cars.

Ideal Design. For the locomotive

$$R = 1.30 + \frac{29}{w} + 0.03\, V + \frac{(0.023\, \sqrt[3]{L_L} + K)V^2}{W}$$

$$= 1.30 + 1.16 + 2.70 + \frac{(0.023 \times 4.3 \times 8100)}{200}$$

$$= 9.17 \text{ lb per ton}$$

For the cars

$$R = 1.30 + \frac{29}{w} + 0.03\, V + \frac{\left[0.124 \times \left(\frac{L_c}{100}\right)^{0.7} + K \right] V^2}{W}$$

$$= 1.30 + 2.32 + 2.70 + \frac{(0.124 \times 3.904 \times 8100)}{500}$$

$$= 14.17 \text{ lb per ton}$$

For the locomotive and cars

$$R = \frac{(9.17 \times 200) + (14.17 \times 500)}{700}$$

$$= 12.73 \text{ lb per ton}$$

The horsepower output at wheels for balanced speed on level tangent track is

$$\frac{12.73 \times 700 \times 90}{375} = 2140 \text{ hp}$$

Adverse Design. For the locomotive

$$R = 1.30 + 1.16 + 2.70 + \frac{(0.023 \times 4.3 + 0.0243)8100}{200}$$

$$= 10.16 \text{ lb per ton}$$

For the cars

$$R = 1.30 + 2.32 + 2.70 + \frac{(0.124 \times 3.904)8100}{500}$$

$$= 14.17 \text{ lb per ton}$$

For the locomotive and cars

$$R = \frac{(10.16 \times 200) + (14.17 \times 500)}{700}$$

$$= 13.02 \text{ lb per ton}$$

The horsepower output is

$$\frac{13.02 \times 700 \times 90}{375} = 2187 \text{ hp}$$

Example—Case No. 3

Consider a power unit articulated with a three-car (eight axles) 120-ton train 198 ft long. Assume a speed of 90 mph.

Ideal Design. The train resistance is

$$R = 1.30 + \frac{29}{w} + 0.03\,V + \frac{\left[0.07 \times \left(\frac{L}{100}\right)^{0.8} + K\right] V^2}{W}$$

$$= 1.30 + 1.94 + 2.70 + \frac{(0.07 \times 1.727 \times 8100)}{120}$$

$$= 14.10 \text{ lb per ton}$$

Horsepower output at wheels for balanced speed on level tangent track is

$$\frac{14.10 \times 120 \times 90}{375} = 406 \text{ hp}$$

Adverse Design. The train resistance is

$$R = 1.30 + 1.94 + 2.70 + \frac{(0.07 \times 1.727 + 0.015)8100}{120}$$

$$= 15.12 \text{ lb per ton}$$

The horsepower output is

$$\frac{15.12 \times 120 \times 90}{375} = 435 \text{ hp}$$

Natural or Ground Winds

The foregoing analysis of train resistance is based upon a still air condition, with the third factor of the equation [R_3] derived from wind-tunnel tests where the flow of air is parallel to the position of the train. This in effect is symbolical of actual operation, where the relative pressures and consequently the resistance elements are created only by the movement of the train itself.

It has been more or less customary in the past when considering wind conditions to assume that the maximum retarding elements were occasioned by a direct head wind and that the force of such wind should be added to the train speed, expressed in the same units, for the determination of resultant values. For example, a train speed of 60 mph and an adverse wind of 20 mph would affect the third value of the equation as follows:

No wind.................................$60^2 = 3600$
20 mph head wind.........................$(60 + 20)^2 = 6400$

which represents 6400/3600, or 1.77 times the normal drag.

DeBell[7] has given test results which indicate the effect of aerodynamic forces brought about by extraneous wind currents, and has established the value thereof at different directional angles by placing the test model obliquely to the air stream. It was thus ascertained that the maximum adverse condition was obtained when the counterbalancing air pressure was in the forward quartering position, at an angle of between 40 deg and 50 deg to the direction of movement. These ground-wind currents apparently exercise an adverse effect from zero angle, representing a direct head wind, to an angle of 120 deg or more. An advantage is reflected from this point to a direct tail wind. As expressed in a relationship to the square of the combined train speed and head wind, the increase in resistance value of the 40 deg to 50 deg forward quartering wind is of the order of 1.25 when the wind velocity is equivalent to one third of the train speed and 1.50 when the wind velocity equals the train speed.

The foregoing remarks under this subject are of more or less academic interest, because from a practical standpoint the wind varies from all directions and at different intensities, although for any given trip it is necessary to reckon upon some character of adversity which can be estimated as the square of the total, that is (train speed + wind velocity)^2. For extreme accuracy, weather-bureau records can be obtained for the territory considered. As this paper is concerned more with the application of figures for general use, it is believed that the equivalent of a direct head wind of 10 mph should be taken as a practical value for schedule calculations.

Quartering, or direct side winds, also affect flange friction R_2 and possibly, to a minor extent, journal friction R_1 due to pressure on end thrust bearings. These elements have not been considered in this analysis, due to lack of information on the subject.

Track Curve Resistance

The unit of track curve resistance appears to be uniformly established at 0.8 lb per ton per deg. This must be considered in train-resistance calculations. The alignment of the road in question must be studied, the radius of each curve multiplied by its length and the total of the resultants divided by the total length, including tangent track, of the particular section being analyzed. The average degree of curvature and the corresponding unit train resistance will be thus obtained.

Air Conditioning and Lighting

The introduction of air conditioning on railroad cars, produces a power requirement element of considerable proportions which in many cases must be converted into train-resistance units if the available total output at the motive-power wheels is used as a basis for train-operating characteristics. A lesser value must be added for lighting energy. In order to obtain proper results, the average of the maximum requirements for mechanical or electromechanical air-conditioning equipment may be taken as 25 hp per car, and the requirements for electric lights and battery charging may be taken as 5 hp per car, or a total of 30 hp per car, at speeds of 30 mph and higher. This power input to axle generators can be reduced to train-resistance values according to the following example for a 50-ton car:

$$\text{At 30 mph } \frac{\text{hp} \times 375}{S \times W} = \frac{30 \times 375}{30 \times 50} = 7.5 \text{ lb per ton}$$

$$\text{At 90 mph } \frac{\text{hp} \times 375}{S \times W} = \frac{30 \times 375}{90 \times 50} = 2.5 \text{ lb per ton}$$

At the slower speed, the power for air conditioning and lighting will exceed that required on level track for the remaining features of train operation.

The foregoing applies in part to steam air-conditioned cars. In this case, where steam motive power is used, the required amount of steam (250 lb per car) will cause a decrease in the boiler capacity available for traction and consequently reduce the wheel output, as expressed in tractive effort at a given speed, if the boiler and not the cylinders is limiting. Some additional axle-generator output is also required to operate certain air-conditioning auxiliaries, but not as much as that necessary for mechanical or electromechanical equipments.

For the streamlined articulated trains, with power units, it is the practice to supply air conditioning and lighting through the medium of an auxiliary generator driven from the main engine unit, or from an auxiliary engine set. In these cases the required power does not represent a deduction from that considered as available for traction purposes, hence the train-resistance units are not affected.

[7] "Effect of Natural Winds on Air Drag," by G. W. DeBell, *Railway Mechanical Engineer*, vol. 110, April, 1936, pp. 145–147.

Following are some examples of specific cases to show anticipated resistance units, lacking grade increments that depend entirely on profile conditions; but with assumed head wind, air-conditioning, lights, and curve-resistance units added. The streamline design and factors affecting wind resistance are assumed as having been worked out to the best advantage.

Example No. 1

Consider a streamlined 200-ton locomotive 80 ft long hauling a ten-car train, the cars of which are streamlined, weigh 50 tons each, are 70 ft long, and have an effective perimeter of 40 ft. The cars are equipped with electromechanical air-conditioning equipment and electric generators, the power requirements of which are 25 hp and 5 hp per car, respectively. Assume a head-wind velocity of 10 mph, a train speed of 90 mph, and an average track curvature of 30 min.

The resistance of the locomotive is

$$R = 1.30 + \frac{29}{w} + 0.03\,V + \frac{(0.023\sqrt[3]{L_L})V^2}{W}$$

$$= 1.30 + 1.16 + 2.70 + 4.95$$

$$= 10.11 \text{ lb per ton}$$

For the cars

$$R = 1.30 + \frac{29}{w} + 0.03\,V + \frac{\left(0.0694 \times \left(\frac{L_c}{100}\right)^{0.88}\right)V^2}{W}$$

$$= 1.30 + 2.32 + 2.70 + 7.69$$

$$= 14.01 \text{ lb per ton}$$

For air conditioning and lights

$$R = \frac{30 \times 375}{90 \times 50} = 2.50 \text{ lb per ton}$$

Therefore, the total resistance for the cars is 2.50 + 14.01 = 16.51 lb per ton. For the locomotive and cars

$$R = \frac{(10.11 \times 200) + (16.51 \times 500) + (0.4 \times 700)}{700}$$

$$= 15.09 \text{ lb per ton}$$

The horsepower output at wheels for balanced speed on level track is

$$\frac{15.09 \times 700 \times 90}{375} = 2534 \text{ hp}$$

Example No. 2

Consider a locomotive-hauled train the locomotive of which is the same as that used in example No. 1 and the cars of which are not streamlined (standard) but have the same proportions, weights, and air-conditioning and lighting equipment as the cars in example No. 1. Assume also the same head-wind velocity of 10 mph, same speed of 90 mph, and same average track curvature of 30 min as used in example No. 1. Then the resistance offered by the locomotive is 10.11 lb per ton, as calculated in example No. 1. However, for the cars

$$R = 1.30 + \frac{29}{w} + 0.03\,V + \frac{\left[0.124 \times \left(\frac{L_c}{100}\right)^{0.7}\right]V^2}{W}$$

$$= 1.30 + 2.32 + 2.70 + 9.69$$

$$= 16.01 \text{ lb per ton}$$

For air conditioning and lights

$$R = \frac{30 \times 375}{90 \times 50} = 2.50 \text{ lb per ton}$$

Therefore, the total resistance of the cars is 2.50 + 16.01 = 18.51 lb per ton. For the locomotives and cars

$$R = \frac{(10.11 \times 200) + (18.51 \times 500) + (0.4 \times 700)}{700}$$

$$= 16.51 \text{ lb per ton}$$

The horsepower output at wheels for balanced speed on level track is

$$\frac{16.51 \times 700 \times 90}{375} = 2774 \text{ hp}$$

Example No. 3

Consider a streamlined articulated eight-axle 198-ft train weighing 120 tons. Assume the head-wind velocity to be 10 mph, the train speed to be 90 mph, and the average track cruvature to be 30 min. The train resistance

$$R = 1.30 + \frac{29}{w} + 0.03\,V + \frac{\left[0.07 \times \left(\frac{L}{100}\right)^{0.8}\right]V^2}{W}$$

$$= 1.30 + 1.94 + 2.70 + 10.07 = 16.01 \text{ lb per ton}$$

The total resistance including track curvature is

$$\frac{(16.01 \times 120) + (0.4 \times 120)}{120} = 16.41 \text{ lb per ton}$$

The horsepower output at wheels for balanced speed on level track is

$$\frac{16.41 \times 120 \times 90}{375} = 473 \text{ hp}$$

Conclusion

It has been the purpose of this article to set forth all of the factors affecting train resistance, which apply in general to modern railroad passenger-train operation. If analyzed in a critical manner for a particular set of conditions, undoubtedly minor adjustments will be in order since resistance units will be affected by details in the shapes of such details as the head end, tail end, roof, wheel fairings, and window embrasures. It is believed, however, that for ordinary use the formulas herein given, and the remarks applicable thereto, will be of service.

Sanforizing Methods Up to Date

By C. H. RAMSEY,[1] PATERSON, N. J.

After commenting briefly on the increase in the production of sanforized shrunk goods of over 824 per cent in five years, which he states is one of the most startling extensions of a new process in the history of the textile industry, the author describes the types of machine that were used in 1930 when the process was more or less of an experiment. The process is next outlined, and the different types of machine that are now commercially available are described. One of these finishes fabric on one side only, while the other turns out cloth that is accurately shrunk in both warp and weft to its potential wash shrink and has an acceptable finish on both sides. The mechanical means provided to secure the proper relation of the different units of the machine and the prevention of scorching of either the cloth or the fabric are described.

ONLY SIX years ago, sanforizing was considered as an experiment. The three units of equipment then in operation processed only 364,000 yd of cloth. Five years later, the 80 machines installed in 51 plants processed 300,000,000 yd, and, by 1935, the production of sanforized shrunk goods had increased over 824 per cent, as compared with the volume of five years earlier.

The process and machinery used commercially were described in a paper that was presented at the 1931 Annual Meeting of The American Society of Mechanical Engineers.[2] The side of the early machines was left open, thus ignoring the safety factor, leaving moving parts unprotected, and allowing wasteful radiation of heat from cylinder heads and side walls. The small drying cylinder of this machine was at the top, and its effective envelopment by the blanket without recourse to additional guide rolls, which is undesirable, was impossible. This construction prevented ready access to the drying cylinder, required excessive headroom, increased the difficulty of changing the blanket, and precluded the full skying of blanket and processed fabric over the rising heat of both cylinders.

In these machines, the cloth is laid on the blanket at the beginning or point of greatest expansion, and pressure of the electrically heated ironing shoes causes it to adhere. As can be seen from Fig. 1, the shoe is shaped to hold the cloth against the expanded element until it makes contact with the drying cylinder that moves down to receive it. The surface of the blanket, contracting as its curvature is reversed, shrinks the web adhering to it in direct proportion. This shrink will always be the same for any given thickness of blanket and will exceed that necessary to meet the potential wash-shrink dimension. However, the surface speed of the drying cylinder is proportioned, through adjustable

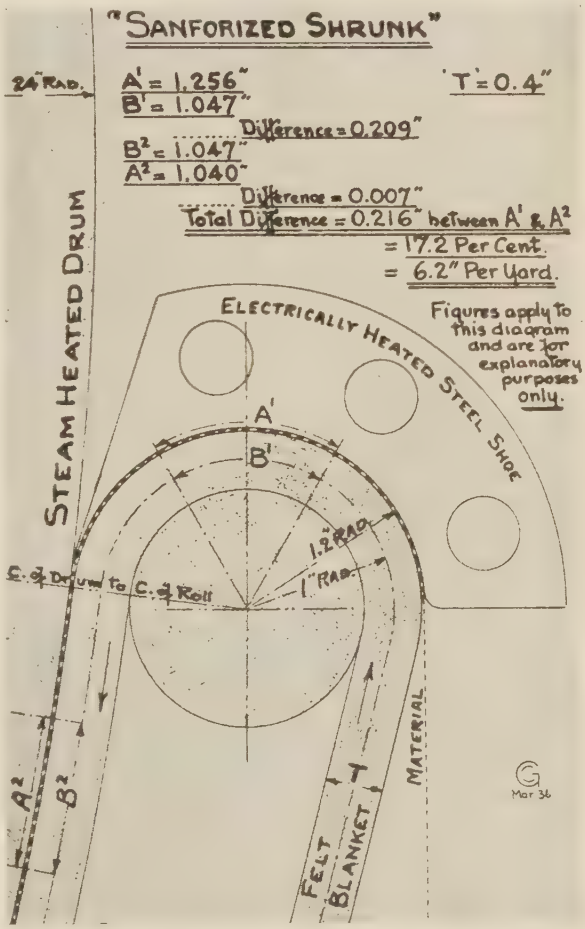


Fig. 1 Modified Palmer of the Sanforizing Apparatus Which Shrinks the Fabric to Length

gear connections, to the shrink required and will pull the fabric sufficiently by warpwise tension to correct this overshrink.

Enclosing Sides of Machine Increases Production

In a more recent sanforizing modified palmer unit, which is shown in Fig. 2, the drying cylinder has been lowered and a highly desirable streamline effect has been secured. This arrangement provides the maximum skying of both blanket and fabric over the rising heat from both cylinders, which is further induced by enclosing the sides of the machine and thus increasing production. Obviously, the enclosure is also highly conducive to the

[1] President, Morrison Machine Co. Mem. A.S.M.E. Mr. Ramsey's connection with the metal-working industry dates back to 1896 when he was employed by John Royle & Sons, Paterson, N. J., as a machinist's apprentice. In the 17 years that he was associated with this firm, he was, successively, journeyman machinist, draftsman, machine designer, and superintendent. He secured his mechanical and engineering education by supplementing his practical experience with reading and study, correspondence-school courses, private tutors, and special instruction in machine design. Immediately after leaving John Royle & Sons, Mr. Ramsey purchased an interest in the Morrison Machine Co., also of Paterson, builder of textile and power-transmission machinery. He became president of the company shortly after becoming associated with it and has held this position for more than 20 years.

[2] "Sanforizing Process," by Sanford L. Cluett, Trans. A.S.M.E., vol. 55, 1933, paper TEX-55-2.

Contributed by the Textile Division and presented at the Annual Meeting of The American Society of Mechanical Engineers, held in New York, N. Y., Nov. 30 to Dec. 4, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until July 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Fig. 2 A More Recent Development Showing the Ironing-Shoe Assembly

safety and comfort of the operator, cleanliness of the fabric, and protection to the moving parts of the machine.

During the shrinking process, the cloth passes from left to right. The first unit, which is called the holdback or feeding machine, consists essentially of a pair of draw rolls before which tension devices and cloth guiders are mounted. This and each modified palmer unit are equipped with quick-change gearboxes to keep them in the proper relation to each other for the shrink required by the fabric being processed. The gearbox on the feeding machine has seven change gears controlling the shrink in increments of 1 in. per yd, while that on the modified palmer has three shrink gears giving increments of $^1/_4$ in. per yd. Thus, any shrink from 0 to $7^3/_4$ in. per yd which the blanket is capable of producing is readily obtainable. In addition, gears securing actual stretch of the fabric, as well as synchronism of the units, are also provided.

Attached to the feeding machine is a set of atomizer heads for spraying a fine mist of water on either or both sides of the fabric as may be required. Thence, the cloth passes over a system of steaming pipes, which, together with the atomizers, render the cloth plastic and susceptible to the changes about to take place.

On the entering end of the modified palmer unit, an adjustable-type spreading device causes the introduction of the cloth to the flexed shrinking element in proper width and free from wrinkles or scrimps. Between the feeding machine and the spreading device, the cloth, in a plastic condition, is held under enough warpwise tension to crinkle the weft threads sufficiently to meet or slightly exceed the previously determined wash-shrink potential dimension, and the spreading device brings the cloth to the exact width required and delivers it to the warp shrinking element without further change. This spreader arrangement is still useful for handling fabrics belonging to the denim family but has been superseded by a more accurate device for other cloths where greater uniformity is required.

Blankets of various thicknesses are used to secure definite shrink requirements. As all blankets are subject to wear and reduction of thickness in use, a series of feed rolls with diametral increments of $^1/_{32}$ in. is provided to maintain complete contact between the shoe and the cloth, the resilience of the blanket rendering more minute increments unnecessary. The woolen belt or blanket is endless and is provided with means for confining the sidewise creep within the limits of the cylinders over which it rides. Once, this was manually controlled but is now accomplished automatically by a motor-driven guide roll that is actuated by a mercury switch provided with suitable detector fingers. This guide roll holds the blanket near the center of the cylinder periphery, allowing only a very small lateral movement.

The electrically heated shoes are thermostatically controlled with a 15-F differential and remain in contact with the cloth or the blanket only while the machine is in motion. If, for any reason, the machine stops, the shoes automatically rise from the operating position after it comes to a full stop, thus precluding the possibility of scorching either fabric or blanket. This is accomplished by a governor-type circuit breaker that lifts the shoes by gravity-actuated balance weights, and, as the shoes rise, the current is automatically shut off. Coincidentally with the machine starting, the current is switched on as the shoes return to the operating position where they are held by a solenoid valve-controlled air cylinder.

The processed fabric leaves the cylinder and blanket accurately shrunk in both warp and weft to its potential wash shrink and permanently set in this condition. In addition, the shrinking process has improved the finished appearance of the fabric, the full crinkle of the fibers catching and reflecting the light. Finally, the processed cloth is lightly plaited down into waiting trucks ready to be folded and packaged for shipment.

Duplex Machine Developed to Finish Both Sides of Fabric

As the processed fabric leaves the machine, one side has an entirely different surface from the other. On several fabrics, this is perfectly satisfactory, but, on many others, this is definitely objectionable, and the duplex machine was developed to meet this condition. A battery of these machines, as viewed from the

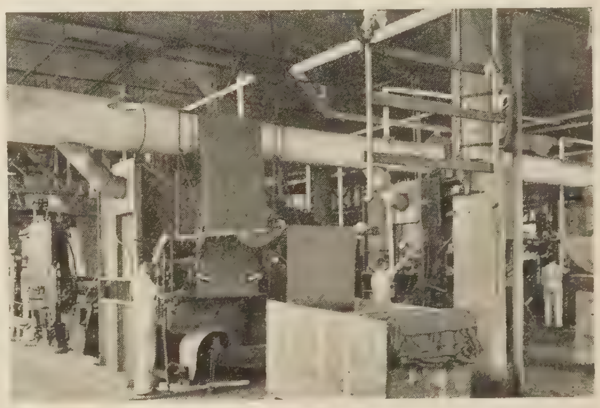


Fig. 3 Entering End of a Battery of Duplex Machines

entering end, is illustrated in Fig. 3. An additional modified palmer of smaller size, sometimes called a reverse finisher, has been added. The cloth passes over an atomizer, which is located between the two modified palmers and slightly moistens the side of the fabric that was against the blanket of the first machine. This moistening usually is not sufficient to penetrate the fabric. The cloth then passes up and around the heating cylinder of the second modified palmer unit with the moistened face of the cloth against the heating cylinder, and an equally acceptable finish on both sides is secured.

Fig. 4 is a close-up of the clip expander, which precedes the main modified palmer unit in the duplex machine. This resembles a miniature tenter and has small automatic clips that grip the edges of the fabric and keep the width uniform and accurate within the limits of the cloth being processed. The machine is connected to the power source by a telescopic shaft and can be moved back and forth over the track on which it rides on flanged wheels without disconnection. Stops are provided on both ends of the track to prevent overtravel and can be adjusted to set the expander in the correct relation to the shrinking element. Motion back and forth on the tracks is easily secured by a handwheel and also provides ready access to the shoes and shoe area to facilitate adjustment and replacement of shoes, feed rolls, and blanket. Vertical adjustment is also important; hence, the frame is hinged at the entering end, and the delivery end can be raised or lowered as required. The expander can be locked in either the operating or nonoperating position by a clamping bracket which also acts as a support for the telescopic-shaft envelope.

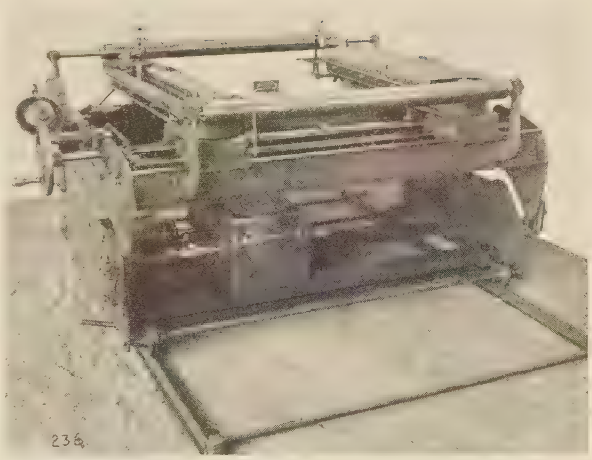


Fig. 4 Another View of the Same Battery, Showing the Clip Expander at Work

The most modern type of simplex sanforizer is fitted with a main cylinder that is 84 in. in diameter, a clip expander, and a new skying device in the steaming chamber. This device consists of a bronze frame supporting 11 brass rollers that are mounted on brass shafts with stainless-steel ball bearings. With it, the cloth remains in the moistening area much longer, which materially increases the plasticity. A unit of this type is shown in Fig. 5.

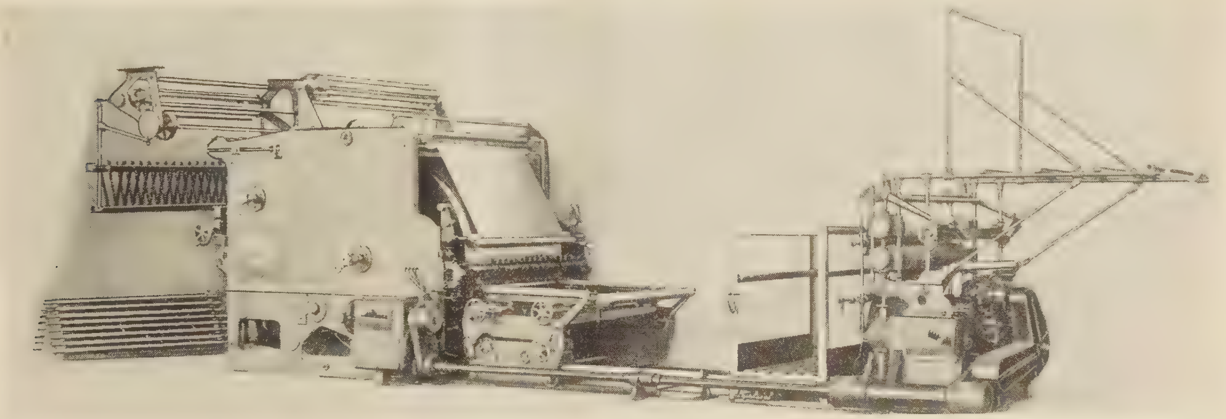


Fig. 5 Latest Type of Simplex Sanforizing Machine

Discussion

New Spring Formulas and New Materials for Precision Spring Scales[1]

R. F. Vogt.[2] The authors have analyzed very admirably the helical-spring problem, and contributed thereby much to the general knowledge of the characteristics of helical springs. It may be of interest to know, however, that the authors' Equation [38] may be changed advantageously into a more convenient form by substituting f for $H - H_0$, where f designates the spring deflection due to the load P. Making this substitution in the authors' Equation [38] and rearranging, the equation becomes

$$f^2 \frac{PR_0^2}{3GJL}\left(3 - \frac{2GJ}{EI}\right) + f\left[1 + \frac{PR_0^2H_0}{GJL}\left(3 - \frac{2GJ}{EI}\right)\right] + \frac{PR_0^2H_0^2}{GJL}\left(1 - \frac{GJ}{EI}\right) - \frac{PR_0^2L}{GJ} - \frac{KLP}{2AG} = 0$$

which may be simplified into

$$f^2 \frac{1}{3L}\left(3 - \frac{2GJ}{EI}\right) + f\left[\frac{GJ}{PR_0^2} + \frac{H_0}{L}\left(3 - \frac{2GJ}{EI}\right)\right] + \frac{H_0^2}{L}\left(1 - \frac{GJ}{EI}\right) - L - \frac{KLd^2}{16 R_0^2} = 0$$

or

$$af^2 + bf + c = 0$$

from which

$$f = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

In these equations H_0 is the height of the helix when the load $P = 0$, which load P is positive when the load extends the spring, and negative when it compresses the spring.

Due to the curvature effect of the spring bar, the deflection for pure-shear load is only one half of the amount provided by the authors; the explanation for this characteristic is given by Röver.[3]

After it was shown by the authors that the deflection curve of the helical spring is not a straight line, as indicated by the conventional spring formula, it likely will interest some readers to know the amount of inaccuracy involved by the use of the conventional spring formula. For this purpose the writer determined the deflection resulting by the use of the various formulas for a spring of the following specifications: $d = 1$ in., $L = 100$ in., $G = 11{,}700{,}000$ lb per sq in., and $G/E = 0.392$. For the tension spring $H_0 = 5.3$ in., and for the compression spring $H_0 = 8.5$ in. The deflections for $P = 4000$ lb are: $f_1 = 3.13413$, $f_2 = 3.160248$, $f_3 = 3.1659218$, and $f_4 = 3.1493715$.

The first value f_1 is derived from the conventional formula $f_1 = PR_0^2L/GJ$ in which $\cos^2 \phi$, bending, direct-shear deflections, and influence of change in radius R and wire length L are neglected. The second value, $f_2 = (PR_0^2L/GJ)[1 + 0.3\,(d^2 2/R_0)^2]$, as proposed by the writer[4,5] adds to f_1 the direct-shear deflection. The third and fourth values $f_{3,4} = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$, as developed from authors' calculations, include in addition the bending deflection, the influence of $\cos^2 \phi$, and the change in R_1; f_3 referring to the compression spring and f_4 to the tension spring.

As may be expected, due to the slight change of the coil radius R, the deflection for the compression spring is larger than for the tension spring for the same load and same dimensions of spring, as shown in the foregoing example. The writer's formula for f_2 gives a value which lies between those for the compression and tension springs, while the conventional formulas give a value which is slightly less. These values represent the deflection for a spring loaded to its maximum capacity. The differences, therefore, are maximums. This would indicate that the writer's formula has a maximum error of approximately —0.18 per cent in case of a compression spring, while for the tension spring the error amounts to +0.35 per cent. These percentages decrease in proportion to the load. The conventional spring equation produces an error of —1 per cent for a compression spring, and —0.47 per cent for a tension spring.

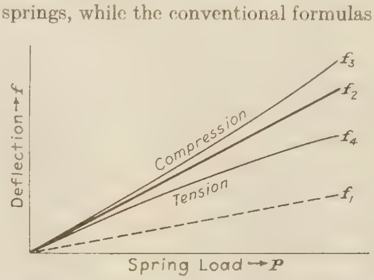


Fig. 1 Deflection Curves

The deflection results for various loads for the example mentioned show that the percentage of error in f_2 in reference to f_3 and f_4 is proportional to the load, or

$$\frac{(f_3' - f_2')/f_3'}{(f_3'' - f_2'')/f_3''} = \frac{P'}{P''} \qquad \frac{(f_4' - f_2')/f_4'}{(f_4'' - f_2'')/f_4''} = \frac{P'}{P''}$$

The deflection curves for f_1, f_2, f_3, and f_4 are shown in Fig. 1 of this discussion, in which the curves of f_2, f_4, and f_1 are exaggerated for demonstration purposes.

R. W. Carson.[6] In connection with an investigation now being conducted to determine the hysteresis or elastic lag in various spring materials, specimens of the "Iso-Elastic" material, mentioned by the authors, were obtained from John Chatillon & Sons. The elastic lag was measured as the slow change in deflection when test pieces were subjected to a steady bending load, the changes being recorded on a chart.

Since these elastic-lag effects are small, highly sensitive measurements are necessary. Mr. Sayre[7] has obtained sensitivity

[1] Published as paper RP-58-12, by M. F. Sayre and A. V. deForest, in the July, 1936, issue of the A.S.M.E. Transactions.

[2] Chief Consulting Engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Mem. A.S.M.E.

[3] "Beanspruchung zylindrischer Schraubenfedern mit Kreisquerschnitt," by A. Röver, *Zeit. V.D.I.*, vol. 57, 1913, pp. 1906–1911.

[4] "Number of Active Coils in Helical Springs," by R. F. Vogt, Trans. A.S.M.E., vol. 56, 1934, paper RP-56-4, pp. 467–476.

[5] "Stress and Deflection of Helical Springs," by R. F. Vogt, Trans. A.S.M.E., vol. 58, 1936, paper RP-58-14, pp. 467–475.

[6] Associate Editor, *Electrical Manufacturing*.

[7] "Elastic and Inelastic Behavior in Spring Materials," by M. F. Sayre, Trans. A.S.M.E., vol. 53, 1931, paper APM-53-8, p. 99.

by using very long gage lengths. The method described by the writer in this discussion is based on sensitive linear measurements of beam deflections, using small specimens that can be readily heat-treated and handled without introducing internal stresses.

Specimens for these tests were rolled from cold-drawn wire of about $^1/_{16}$ in. in diameter to a rectangular cross section of 0.017 in. thick and 0.156 in. wide, and heat-treated at 650 F for 20 min. Strips about 4 in. long were cut from this material and loaded as cantilever beams, measuring deflections with an electronic micrometer sensitive to displacements of less than 0.00001 in.

The measuring instrument uses electronic means for indicating point of contact between a micrometer and the specimen. This principle was incorporated in a measuring device previously described by the writer,[8] but the use of a new type of relay, recently developed by the Westinghouse Electric & Manufacturing Company, has resulted in increased sensitivity and reliability needed to measure the small elastic lag in the Iso-Elastic material.

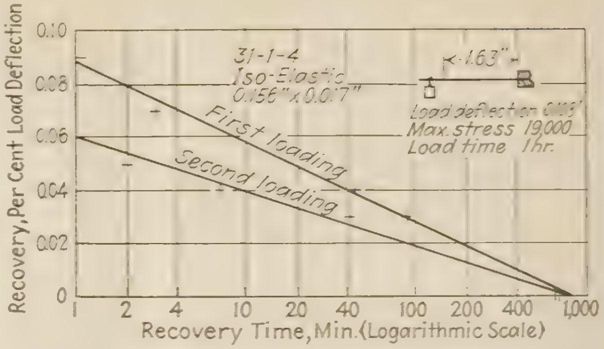


Fig. 5 Recovery Curves of Iso-Elastic Material

[8] "Better Instrument Springs," by R. W. Carson, *Electrical Engineering*, vol. 53, February, 1934, pp. 282–286.

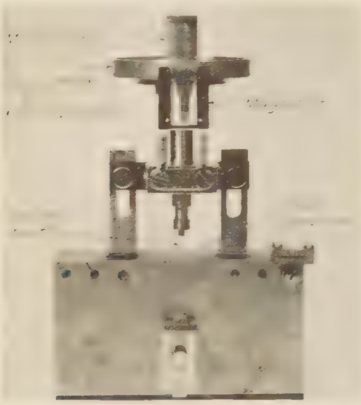


Fig. 2 Electronic Micrometer

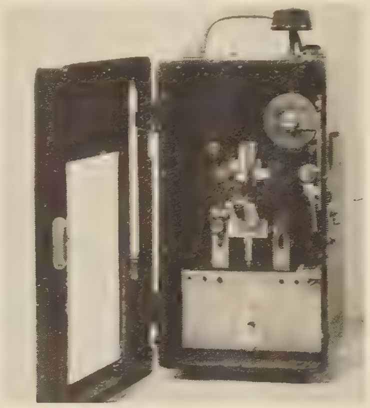


Fig. 3 Electronic Micrometer With Drive Used to Set It to Exact Point of Contact on the Specimen

With the redesigned equipment, permanent records of ribbon deflections are made on a paper chart that can be read to 0.000002 in. With this increased sensitivity, reliable and accurate measurements of elastic lag are made on relatively small test specimens under deflections producing maximum fiber stresses as low as 10,000 lb per sq in., even with specimens having low inherent hysteresis.

The measuring unit, shown in Fig. 2 of this discussion, consists of a block of brass on which the micrometer is supported on an insulating bracket. The end of the micrometer is fitted with a needle point which is brought into contact with the specimen by screwing down the micrometer. A large-diameter barrel on the micrometer, viewed through a magnifier lens assists in reading the micrometer, while a constant tension thread drive through a gear reduction, shown in Fig. 3 of this discussion, aids in setting the micrometer to the exact point of contact.

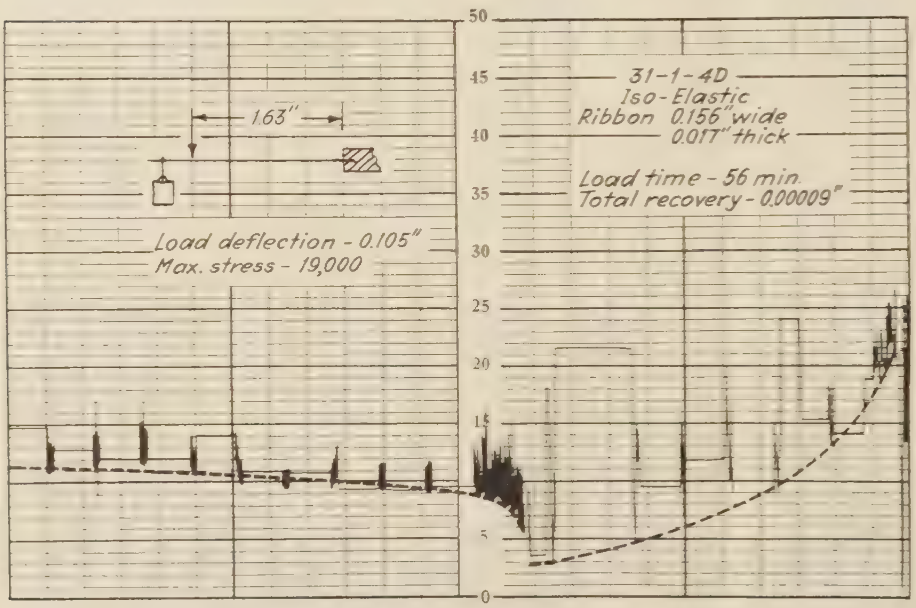


Fig. 4 Record Made by the Electronic Micrometer
(Test starts at right.)

Records are made by the instrument on a continuous-roll chart advancing 4 in. per hr. The chart, which is $5^1/_2$ in. wide, carries 10 main divisions, each with five small divisions. The recorder is designed so that each small division is 0.00001 in., while full scale is 0.0005 in. In the portion of the chart shown here, the test starts at the right, and only a part of the recovery curve is reproduced.

In conducting a test, specimens are clamped in the micrometer support, and allowed to rest several hours until a stable condition is obtained. The ribbons are then stressed for 1 hr by hanging a weight on the ribbon, and the recovery measured after removing the weight.

The instrument automatically makes a group of records of ribbon position during about 1 min in each period of 6 min. These automatic records are obtained by the use of a small electric motor in the recorder which screws the micrometer down until contact is made. This contact through the electronic relay reverses the motor, withdrawing the micrometer from contact, and the operation is then repeated.

In a typical record, shown in Fig. 4 of this discussion, the recorded points indicating ribbon position are connected by a smooth curve. To show more accurately the rapid changes in ribbon deflection occurring immediately after removal of load, the recorder is operated continuously for several minutes.

From these records, the total recovery is measured, and the ratio of total recovery to load deflection determined. For stable conditions obtained after two or three preliminary tests, the creep recovery or elastic lag for the Iso-Elastic specimens used in these tests is from 0.04 to 0.06 per cent of the load deflection.

Disregarding the effects measured during the first minute after removing the load, the recovery follows a logarithmic curve to final recovery, as shown in Fig. 5 of this discussion, with final recovery occurring in about 10 to 12 hr under the load conditions given on the curve. Conditions during the first minute seem to follow a different routine. For perhaps 20 sec after unloading nothing much happens. Then the spring rapidly recovers about one third of the creep during the first 5 min. The remainder of the creep follows an averaged logarithmic curve.

The irregularities shown in the recovery portion in Fig. 4 of this discussion are characteristic. These irregularities are of the order of 10 times the sensitivity of the device, and are not instrument errors, nor are they produced by vibration of the specimen. All attempts to eliminate these irregularities have failed. At present the variations are averaged in plotting the data.

New Laboratory Data Relative to Embrittlement in Steam Boilers[1]

E. P. Partridge.[2] The information presented by the authors, and by W. C. Schroeder and A. A. Berk in another paper,[3] relative to the fundamental part played by silica in promoting embrittlement of boiler steel exceeds in importance anything that has been presented on the subject since the inception of the work at the University of Illinois.[4] In Progress Reports Nos. 4 and 6 of the Joint Research Committee on Boiler Feedwater Studies,[5,6,7] it seemed that the extensive data in those reports[5,6] were thoroughly in contradiction with the earlier results given by F. G. Straub,[4] as were also the conclusions of several other investigators, both in this country and abroad. With the discovery of the effect of silica, all of the apparently discordant results can now be explained.

The writer would like to point out at this time that in spite of the 30 years of work on embrittlement, the important effect of silica would have remained unknown if an independent investigation such as the one developed under the cooperative agreement between the Joint Research Committee for Boiler Feedwater Studies[7] and the U. S. Bureau of Mines had not revealed the extent of our ignorance of the fundamental chemical factors in embrittlement. That we now have a clearer view of the subject is due to the the combined efforts of F. G. Straub,[8] W. C. Schroeder,[9] and J. H. Walker.[10] Under the direction of Mr. Walker, every effort was made during 1934 to discover the cause of the discrepancies between the results obtained at the University of Illinois[4] and those obtained at the Nonmetallic Minerals Experiment Station of U. S. Bureau of Mines maintained at Rutgers University, New Brunswick, N. J. Arrangements were made for the exchange of samples of steel, chemicals, and, if it seemed desirable, of test equipment.

The writer would like to emphasize the fact that although he was associated with the investigation conducted at New Brunswick, N. J., from its inception until September 1, 1935, the credit for discovering the action of silica in producing embrittlement belongs only to Dr. Schroeder[9] and A. A. Berk,[11] because the writer left the Bureau of Mines just prior to the work conducted with the sample of commercial caustic supplied by F. G. Straub. From the larger number of specific data given by Dr. Schroeder[3] and the confirmatory information in the authors' paper,[1] it seems safe to conclude that the widely divergent statements in the past concerning embrittlement by caustic soda are now converging to give sounder basis for the further investigations which must be made. Now that we know more accurately how embrittlement is caused, we may be able to develop more intelligently the means for its prevention.

[1] Published as paper RP-58-13, by F. G. Straub and T. A. Bradbury, in the July, 1936, issue of the A.S.M.E. Transactions.

[2] Director of Research, Hall Laboratories, Inc., Pittsburgh, Pa.

[3] "Action of Sodium Silicate and Sodium Hydroxide at 250° C. on Steel Under Stress," by W. C. Schroeder and A. A. Berk, American Institute of Mining and Metallurgical Engineers Technical Publication No. 691, January, 1936.

[4] "Embrittlement in Boilers," by F. G. Straub, Engineering Experiment Station Bulletin No. 216, 1930, University of Illinois, Urbana, Ill.

[5] "Effect of Solution Composition on the Failure of Highly Stressed Boiler Steel," by W. C. Schroeder and E. P. Partridge, Progress Report No. 4 of the Joint Research Committee on Boiler Feedwater Studies and the U. S. Bureau of Mines, and presented at the Annual Meeting of The American Society of Mechanical Engineers, held in New York, N. Y., December 3 to 7, 1934.

[6] "Effect of Solution Composition on the Failure of Boiler Steel at 482 ° F. (250 ° C.) as Measured by Static Tension Tests," by W. C. Schroeder, A. A. Berk, and E. P. Partridge, Joint Research Committee on Boiler Feedwater Studies and the U. S. Bureau of Mines, Progress Report No. 6, June 1, 1935.

[7] The Joint Research Committee on Boiler Feedwater Studies is sponsored jointly by the American Boiler Manufacturers' Association, American Railway Engineering Association, American Water Works Association, Edison Electric Institute, the American Society for Testing Materials, and The American Society of Mechanical Engineers, to study methods of analysis and treatment of boiler feedwater for stationary and railroad practice.

[8] Special Research Assistant Professor in Chemical Engineering, University of Illinois, Urbana, Ill.

[9] Research Chemical Engineer for the Joint Research Committee on Boiler Feedwater Studies, attached to Nonmetallic Minerals Experiment Station, U. S. Bureau of Mines, Rutgers University, New Brunswick, N. J.

[10] Superintendent of Central Heating, Detroit Edison Company, Detroit, Mich. Mem. A.S.M.E. Mr. Walker is chairman of a subcommittee of the Joint Research Committee on Boiler Feedwater Studies, which subcommittee is in charge of the joint investigation on boiler feedwater studies conducted under a cooperative agreement between the Joint Research Committee on Boiler Feedwater Studies and the U. S. Bureau of Mines, and carried out at the Nonmetallic Minerals Experiment Station of the Bureau of Mines at Rutgers University, New Brunswick, N. J.

[11] Analytical Chemist, U. S. Bureau of Mines, Rutgers University, New Brunswick, N. J.

Plunger Lift for Pumping Deep Wells[1]

C. M. Rader.[2] The writer believes that the equipment described by the authors is more important than it is generally considered to be. This is particularly true in fields depleted by gas drives rather than by water or other drives that tend to sustain a

[1] Published as paper PME-58-1, by H. W. Fletcher, in the July, 1936, issue of the A.S.M.E. Transactions.

[2] Assistant Division Superintendent, Phillips Petroleum Company, Oklahoma City, Okla.

relatively high bottom hole pressure which results in the retaining of sufficient energy within the oil body for the moving of the oil from the sand to the well bore.

In Oklahoma, as a rule, fields producing from the Wilcox horizon nearly always fall in the class of gas-drive fields. This is particularly true of the Oklahoma City field, to which field the writer's experience with the Hughes plunger lift has been limited. The same holds true, however, for the Seminole field.

Here, for various reasons including proration, large investments were made at an early date in rather elaborate high-pressure gas systems for purposes of production after natural flow had ceased.

Naturally, once such an investment was made, it had to be utilized to the utmost which meant, to the ultimate depletion of the field if possible. This view, of course, contemplated the nonpurchase of additional equipment for lifting purposes, other than that which used high-pressure gas as a lifting medium. In other words, this view called for the discarding of sucker rod pumping, or its equivalent.

Before the operators could be sold on this latter idea, they had to be assured that whatever equipment they purchased, after gas lift, would carry them through to the end of production. They saw the advantages of the straight plunger lift, as was demonstrated by their numerous purchases, and felt assured that the so-called booster pump could and would be developed in time to finish the job after straight plunger-lift operations ceased to be economical or possible.

It was felt certain that this period would come in most of the wells, for it was early demonstrated that there was no water drive. The work of Ben Lindsly, of the Bureau of Mines, demonstrated that very little gas, which, of course, is the propulsive force driving the oil through the sand to the well bore, would be available when bottom hole pressures became low. It was determined that there would eventually remain but about 1 cu ft of gas per bbl of residual oil per pound of bottom hole pressure after this pressure was reduced below 150 lb per sq in. In addition to these factors, the extreme permeability of the Wilcox sand coupled with relatively close spacing of wells pointed the way to loss of production on the part of the wells equipped with a tool that required any back pressure whatsoever on the sand face for operating purposes. Worse yet, this lost production would go to offset wells in more or less direct proportion to the amount of back pressure exerted against the face of the producing sand in the wells in question. In other words, it was anticipated by some that most of the Oklahoma City wells would eventually fall in the classification of wells 15 and 16 referred to in Table 1 of Mr. Fletcher's paper.

When making these statements, the writer must, in all fairness, refer to an article[3] wherein is a comparison of plunger-lift well production with offset well production. Offset wells were produced by beam pumping. The 1935 average for four wells operated by plunger-lifts was 1853 bbl per month, as compared to 1220 bbl per month for the several offset wells. However, several things are brought to attention by a perusal of this table:[3] First, during January, 1935, the four plunger-lift wells produced 2505 bbl as compared to the 1674 bbl of offset production; whereas, in December of the same year the plunger-lift wells produced but 1213 bbl as against 1091 bbl for the offset wells. From this it is seen that the plunger-lift wells took an average decline of 51.5 per cent during the year as compared to but 34.8 per cent for offset wells. As this decline was coincident with the period in the decline in bottom hole pressure that represented the difference between successful and relatively unsuccessful operation of the straight plunger lift, the writer believes that the beam-pumped wells will still be producing economically after the plunger-lifted wells are abandoned. Second, the wells in question are located on the west edge of the field, well down structurally, and produce from a relatively tight sand not typical of the average Wilcox sand, but more approaching the type wells listed in the upper brackets of the author's Table 1.

The writer's discussion so far has been given mostly for the benefit of those who operate in gas-drive fields only, which, as previously stated, constitute a fairly high percentage of the operations in Oklahoma, from a total production standpoint. The writer has found by experience that where other conditions are present, as outlined by Mr. Fletcher, a fairly large measure of success is assured by the plunger type of operation. There are 32 successful installations still operating in the Oklahoma City field; of this number, ten are in Wilcox-sand wells, consisting of six $2^1/_2$-in. wells, two 3-in. wells, and two 4-in. wells. The other 22 installations are operating in Simpson-sand wells. Of these 18 are in $2^1/_2$-in. wells, three are in 3-in. wells, and one is in a 4-in. well.

If the writer's information be correct, there were originally some 92 units purchased for the Oklahoma City field, 48 of which were originally installed in Wilcox-sand wells; these include 27 in $2^1/_2$-in. wells, 13 in 3-in. wells, and 8 in 4-in. wells. There were 44 installations originally made in lower Simpson-sand wells; these include 31 in $2^1/_2$-in. wells, 8 in 3-in. wells, and 5 in 4-in. wells. These purchases were begun in January, 1934.

To the best of the writer's knowledge, some 12 Simpson-sand wells and but one Wilcox-sand well have been carried to abandonment with plunger-lift equipment.

Of the 44 Simpson-sand wells originally equipped with this tool, 22 are still being produced in this manner, whereas but 9 of the 48 Wilcox-sand wells originally so equipped are being so produced.

Difficulties arising from paraffin deposition have always been of major importance in the production of oil in the Oklahoma City field. A progressive study of the operation of some 26 wells, most of which were in the Wilcox sand, indicated an average lost time due to this cause of approximately 5 or 6 per cent. This is a relatively small factor, especially when considering the fact that it normally requires the time of but one man for an hour, more or less, to get a well back on production once the stoppage occurs. Furthermore, considerable advancement has been made both in plunger design and otherwise for the combating of this trouble.

It has been noted that less paraffin trouble was experienced by 4-in. than 3-in. installations, and less by 3-in. than $2^1/_2$-in. ones. This is explained by the greater weight of the larger plungers allowing them to cut by or through paraffin bridges when falling back down the hole, and by the greater total force exerted upward by the larger plungers, for any given working pressure.

TABLE 1 RESULTS OF $2^1/_2$-IN. PLUNGER LIFT IN A TEST WELL IN THE OKLAHOMA CITY FIELD

Date	Average daily production, bbl	Average daily operation, hr	Average gas-oil ratio	Highest production, bbl per day	Minimum gas-oil ratio
October 27, 1935 November 15, 1935	130.0	19.0	4240	204	2220
December 9, 1935 January 9, 1936	90.3	20.5	2617	167	1490
January 23, 1936 February 22, 1936	119.0	20.5	2000	186	2620
March 17, 1936 March 21, 1936	99.2	19.6	2720	120	2570

Naturally, greater production is obtained by use of the larger plungers for any given working pressure, or, conversely, any given production can be obtained by use of lower pressures in the larger installations. Here, however, economics of initial investment enter, which, in conjunction with the booster-pump possi-

[3] "Producing Wells to Exhaustion by Gas-Lift," by S. F. Shaw, *Oil Weekly*, vol. 81, April 6, 1936, Table 3, p. 20.

bilities, in the majority of cases, favored the purchase of the smaller-diameter pumps.

Field experimentation with the booster pump began early in 1935, and has progressed intermittently since. It must be remembered that production depths run around 6500 ft, and allowables must be obtained if at all possible. Mistakes and false starts were inevitable where no fund of experience was available to direct the progress of the work.

Several designs for a $2^1/_2$-in. lift have been tried in a test well in the Oklahoma City field from time to time, with the results shown in Table 1 of this discussion. Down time averaged 4 hr per day, which was due largely to the freezing of input gas lines, together with a few stoppages resulting from sand and paraffin. Prior to the installation of the booster pump, this test well averaged approximately 40 bbl per day on straight plunger lift, with an input ratio of upward of 5000 cu ft per bbl.

Evan Just.[4] The writer can state that his experience in the Oklahoma City oil field corroborates the author's statements. In that field, producing from a depth of 6400 ft, 4-in. plunger lifts produce approximately 2.5 bbl per day per lb of flowing pressure, or an average of 175 bbl per day; 3-in. plunger lifts produce approximately 1.2 bbl per day per lb of flowing pressure, or an average of 109 bbl per day; and 2-in. plunger lifts produce approximately 0.6 bbl per day per lb of flowing pressure or an average of 37 bbl per day. Lifting costs, including depreciation, have been approximately one half as much as the costs of rod pumping, and the percentage of down time, which has averaged 7 per cent for plunger lifts, has been approximately one third of the down time of rod pumps. The cost of reconditioning the wells per barrel of production has been approximately one tenth the corresponding cost for rod pumping.

The principal cause of down time has been paraffin accumulation. The capacity of the plunger lift to operate in sandy wells has been comparatively remarkable.

The low reservoir pressure and high productivity index described by the author were encountered in the Wilcox zone of Oklahoma city. Where flowing pressures declined below 60 lb per sq in. the 4-in. plunger lift could not compete with the rod pumps.

Author's Closure

Mr. Rader's comments regarding the importance of the booster pump, in areas where porous strata are depleted to low end pressures, are much to the point. It is unfortunate that the necessity of maintaining allowables, and the delays in securing the necessary equipment required to make such changes as were indicated, so prolonged the experimental period that the device was not yet in commercial form at the time pressures had declined to such a value as would require its use. While the unit is necessarily more complicated than the straight plunger lift (the chief drawback being the use of a "macaroni string" laced to the working string and supported at the proper intervals for furnishing the gas supply) there has been comparatively little mechanical trouble and the operating unit has been removed and replaced in about three hours without disturbing the pipe. Work is still in progress along these lines and gives fair promise of an ultimately satisfactory conclusion.

The figures presented by Mr. Just, comparing as they do the performance of a number of units operating under commercial conditions, are interesting. The sharp reduction of down time and the even greater lowering of maintenance costs justifies the original conclusion that the use of this equipment would result in an appreciable reduction of lifting costs.

[4] Petroleum Engineer, The Carter Oil Company, Seminole, Okla.

The Influence of Cutting Fluids on Tool Life in Turning Steel[1]

Arthur H. Adams.[2] This paper, which is a progress report of the Subcommittee on Cutting Fluids of the A.S.M.E. Special Research Committee on the Cutting of Metal, is an important step toward the solution of the cutting-fluid problem, and it is to be hoped that the committee will be able to continue its important work. The writer believes that some day there will be developed new and startling cutting fluids based on an unorthodox hypothesis as to their action, and he is of the opinion that this report contains justification for this belief. This moves the writer to make the criticism that the report stops blandly after the presentation of certain facts which seem to demand interpretation, and to present by the Socratic method an unorthodox hypothesis which will interpret some of the main points of the paper. These questions and answers are as follows:

Question 1: What is the main function of a cutting fluid? Answer: To lubricate the most difficult of bearings, that is, bearings between the tool and the work, and between the tool and the chip in metal-cutting operations.

Question 2: Is not the heat-removing function very important? Answer: It is probably secondary to lubrication.

Question 3: How is the answer to question 2 justified? Answer: First, by a process of reasoning that, accepting just one assumption, justifies it rigorously. Second, by the way this hypothesis, in which lubrication is the main mechanism, seems to explain otherwise uncoordinated data.

The process of reasoning mentioned in the foregoing answer is developed as follows:

Question 4: How does a tool finally fail? Answer: By becoming so dull (worn) that the thereby increased friction develops heat fast enough to overheat the tool, particularly the edge, and causes it to lose temper.

Question 5: How can a cutting fluid postpone such failure? Answer: First, it can reduce the rate at which power is used in friction by getting on the tool surfaces and doing something we will have to term "lubrication" although it is so imperfect that it bears little resemblance to ordinary lubrication. At any given stage of tool wear a slightly lessened friction, due even to most imperfect lubrication, yields a double benefit: It reduces both the next increment of wear and the heat generated. With even very imperfect lubrication it takes a duller tool to generate as much heat as without it. Second, a cutting fluid carries away heat and delays the tool in reaching temperatures that cause that loss of temper.

Question 6: Is it not tenable that, by mere carrying away of heat, a cutting fluid can reduce friction and wear?

Answer: So far as the writer knows, data are lacking on the coefficient of friction between hard tool steel and mild steel, under conditions resembling those of dry cutting tools. Therefore, it is possible that under these conditions the coefficient of friction may be found to rise with temperature; in that case cooling would reduce friction. The most nearly applicable data found are on the brakes of railroad cars. Here the coefficient of friction drops very markedly as the brake application is prolonged and as the brakes get hot. The tool frictions in metal cutting within the range below incipient temper loss have, therefore, been assumed not to rise as temperature rises. This important assumption should be checked by special test. If the assumption is seriously wrong the cooling action of the cutting fluid may be more important than the writer believes.

[1] Published as paper RP-58-11 O. W. Boston, W. W. Gilbert, and C. E. Kraus, in the July, 1936, issue of the A.S.M.E. Transactions.

[2] Consulting Engineer, New York, N. Y. Mem. A.S.M.E.

The evidence, however, of practically all speed tool-life data is not in conflict with the assumption.

Question 7: Making that assumption, what must be the effect on tool life of mere cooling?

Answer: There are two conditions to discuss: (*a*) The tool is still in such good shape and the speed is such that heat is not generated fast enough to injure the temper even if there were no cooling. While this condition lasts mere cooling is doing nothing toward postponing failure. (*b*) As soon as the tool is more worn, or if the speed be high enough so that, in the absence of cooling, the temper would be threatened, mere cooling would only then begin to postpone failure.

Let us see about how important this postponement is. Based on the previously mentioned assumption, the rate of wear is not reduced by mere cooling. Therefore, the duller the tool becomes the more power goes into wear (and heat) and the dulling of the tool is accelerated. The life of a tool cooled N deg at failure will be the same as the life of an equivalent uncooled tool of same shape and wear resistance, but of some steel able to stand a temperature N deg higher. Thus the gain by cooling is not cumulative. The gain is that the maximum dullness the tool will stand is increased a little. This is a definite tool-life gain but not a big one. Once a cooled tool is as dull as it can get and still safely run uncooled, it will not take long for it to get as dull as it can possibly run with cooling.

Question 8: If we meagerly lubricate the working area of the tool what are the gains?

Answer: Reduction in coefficient of friction. This proportionately reduces both the power lost in friction (tool wear) and the heat generated. Starting with a given tool condition, mere cooling made no reduction in the next increment of wear. Even meager lubrication makes a reduction in the next increment of wear. And another gain in the next, and the next. Cumulative gains! A slight decrease in the rate of wear for given tool conditions makes a big gain in tool life. Moreover, heat generation is reduced as much as wear; hence, tool temperature will be lower for a given condition of the tool. This fact alone yields much the same noncumulative life extension toward the end of tool life as mere cooling does.

Question 9: If lubrication is the thing, why do we not get better results when proven high-grade lubricants are tried as cutting fluids?

Answer: Because the "bearings" are so peculiar. No matter how good a cup grease you select it will not loosen rusted-in bolts. The cutting lubricant must, in all common sense, be chosen first for ability to penetrate the tool-chip bearing quickly. This bearing has no low-pressure oil entrance. The only oil grooves it has are first the cracks in the chip, which streams swiftly back over the tool, and second, the hard-packed metal particles constituting the so-called "false nose" on the tool point. No good lubricating oil could enter these oil grooves before they leave the tool. Yet that is essential.

Question 10: What properties of a cutting lubricant, then, tend to make it penetrate the tool-chip bearing quickly?

Answer: Low interfacial tension on the metal to be cut and low viscosity are both indispensable. These vary so in relative value from job to job that neither can be set first. Perhaps attention to getting the utmost in low interfacial tension (rapid wetting power) on the work (also on the tool, if not incompatible) will yield bigger dividends than trying for the utmost in low viscosity.

The properties of a good cutting lubricant, according to this hypothesis, must be varied to suit the job. This agrees with practice and explains why it has been so hard to get coordination of cutting-fluid data. If the hypothesis be true, the size and shape of the cutting tool, the depth and width of the chip, the pressure of the chip on the tool, the hardness of the metal, its toughness or brittleness, the affinity or spreading speed of the lubricant, the cutting speeds used, and many other factors all seriously affect the properties a good cutting lubricant needs. Metal that cuts short, i.e., with easily broken chips having good sized fissures, does not need a fluid of as low viscosity as more malleable metal. The higher the cutting speed the swifter must be the penetrating action of the fluid to reach the tool at all.

Question 11: If such swift penetration be required for tough metals and for high speeds, how can a liquid of the requisite fluidity be of any use when it does get near the tool point?

Answer: Anything at all on the tool at the pressure points, even water, is vastly better than a splendid high-pressure lubricant on the outside only. This is the reason why conclusion 9 of the report shows water, and borax water the best of all, for the top speeds.

The case of mineral oil before and after treating with Oildag, as presented in the paper, should be discussed. A corollary of the penetration-lubrication hypothesis, formulated many years ago by the writer, is that some day a suitable low-viscosity, high-flash-point liquid, of high wetting power for metals may be discovered and be made to carry some dispersed solid having, like colloidal graphite, an affinity for steel. By this means the swiftest penetration could be combined with the highest pressure-resisting lubrication. Such a thin fluid would not itself lubricate much, but it would be the penetrant carrier to insure constant rebuilding on the tool of a wear-resisting surface. Such a combination might be a universal cutting fluid. Years ago the writer experimented briefly with kerosene and Oildag in these rôles, with just enough success to become convinced of the correctness of the thought and of the incorrectness of kerosene in that rôle.

Professor Boston's light mineral oil with Oildag renews the writer's enthusiasm for exploration in this territory. Consider the curves M and M-20 of Fig. 10 of the paper. This oil is little better than nothing. We add 0.15 per cent of colloidal graphite and it becomes better than all other fluids tried. Quite remarkable results for so slight a change in the oil itself.

Let us see if the hypothesis can give an answer to this. This neutral oil, without fatty acid, is certainly not as vigorous a wettant for steel as the sulphurized-base oils. Very light, as oils go, it still has a viscosity of a different order from water and the aqueous fluids. It is then inferior in both of those properties found indispensable by the hypothesis. Note, however, that it is a little better than nothing. One therefore asks what effect did the addition of a trifling amount of Oildag have? It cannot be argued that the heat-removing properties were enhanced by its addition.

Let us suppose this oil, which is better than nothing, does penetrate in minute amounts. Possibly traces, clinging on the hot tool next to the chip, become fluid enough to be drawn swiftly into the chip fissures. These traces, when carrying graphite, deposit it sparsely on the tool. This brings about a new effect. It is well known that the wetting power of oil for a graphitized surface is very high. Our oil has suddenly become a vigorous wettant for the tool. This partially overcomes its handicap of having a rather too high viscosity. It gets in, at least in sufficient quantities to maintain a fair film of graphite despite the pressure, particularly at all the lower speeds. The handicap of excessive velocity is still there. The M-20 curve approaches the M curve at the higher speeds.

Suggestion is often better than elaboration. There are a hundred almost equally interesting discussions possible of the data in this one report. Do they not indicate a new field of research which will include the following items?

(*a*) Measurement of heat generated (or of power input) with different fluids, and determination of whether the better cutting

fluid does not invariably generate less heat. This should be a crucial experiment for the hypothesis.

(*b*) Viscosity-temperature data to be determined for all fluids, and wetting-power research for all on different metals.

(*c*) More exhaustive speed-tool-life studies, all interpretable by the light of the penetration-lubrication hypothesis.

(*d*) The job of modifying and refining the hypothesis and reducing to mathematical expression.

(*e*) In the end, perhaps, development of that ideal cutting fluid, or of a series of them for different metals.

Hans Ernst.[3] The tests reported in this paper are of especial interest in that they call attention indirectly to the two principal functions of a cutting fluid, namely, cooling and lubrication. These two functions are independent, and are not here named in the order of their importance; either may assume the paramount rôle under certain cutting conditions. Both are important from the standpoint of chip formation. The built-up edge which precedes the nose of the cutting tool largely determines the finish of the work and the tool wear. The magnitude of this built-up edge depends largely on the lubrication of the tool face and the structure of the metal immediately ahead of the tool; the plasticity of this material is affected by the coolant.

The independence of these functions, and their varying relative importance, is particularly emphasized by the results of the tests on colloidal graphite. In the equation $VT^n = C$, a marked reduction in the exponent n is shown with increasing additions of graphite to the soluble oil, and a still greater reduction by similar additions to the mineral-oil carrier; there is also, in each case, a small reduction in the constant C. As shown by the authors, this combination effects a counterclockwise rotation of the tool-life cutting-speed curve about a point corresponding to a relatively low tool life, thus indicating a marked increase in the tool life, for the lower cutting speeds, and a small reduction in tool life for the higher cutting speeds.

But an increase in the percentage of graphite content, and again a change from a soluble-oil carrier to a mineral-oil carrier, undoubtedly increases the lubricating value of the fluid, particularly where conditions of boundary lubrication are encountered. Thus, it appears that the lubricating function of the cutting fluid is of prime importance at the lower cutting speeds.

On the other hand, at the highest cutting speeds, this increase in lubricating value apparently causes a decrease in tool life. This seeming anomaly may perhaps be explained by the fact that, in general, an increase in the lubricating value (as by changing from the soluble-oil to the mineral-oil carrier) is accompanied by a reduction in the specific heat, with a corresponding reduction in the cooling effect. Thus, at the highest cutting speeds, the reduction in cooling effect overshadows the improvement due to better lubrication. As the authors have mentioned, the thermal conductivity or the ability of the fluid to carry off heat, is not necessarily a direct function of the specific heat.

Further evidence for this is given by the curve for the borax-water solution, that is, curve *WB* in Fig. 5 of the paper. Here the lubricating value is obviously very small, yet the constant C is higher than that of any of the other cutting fluids in this series of tests. This is probably due to its high value as a coolant.

From the foregoing it appears evident that the ideal cutting fluid is one which combines to the fullest extent high cooling effect and high lubricating value (under the conditions of temperature and pressure which exist at the nose of the cutting tool); it is for this reason that improvement is generally obtained by the use of sulphur or some other substance which gives the cutting fluid the characteristics of an extreme-pressure lubricant. As these two properties are largely opposed to each other in commercial cutting fluids, some cooling effect must usually be sacrificed at the lower cutting speeds in order to obtain the maximum lubricating value; and conversely, some lubricating value must be sacrificed at the higher cutting speeds in order to obtain the maximum cooling effect.

Raymond Szymanowitz.[4] The authors' formula for the cutting-speed tool-life relationship, $VT^n = C$, has an economic as well as a mathematical meaning. The exponent n, as was pointed out, is affected by the cutting fluid used, other conditions remaining constant. This exponent which is a mathematical symbol for the rate of change of cutting-speed with tool-life, is shown to decrease appreciably when using colloidal graphite in plain mineral oil as the cutting fluid. From an economic standpoint, this means that the manufacturers' present equipment can be speeded up to meet seasonal or emergency demands with less tool trouble.

While discussing the economic phase of the subject, the writer would like to point out that the addition of colloidal graphite to plain mineral oil yields an increase in production of 25 per cent, at an increase in cost of only 3.9 per cent. To the person who would like to make some practical use of this research report, these figures seem to be the crux of the matter. These figures have been arrived at in a manner similar to those given in the paper.

For a constant tool life of 300 min as seen from Fig. 10 of the paper, the cutting speed for the plain mineral oil is 77 fpm; for the sulphurized oil it is 86 fpm; and for the mineral oil plus colloidal graphite (*M*-2-0) it is 96 fpm. The increase in speed or production for the sulphurized oil over the plain mineral oil is approximately 12 per cent, and for the mineral oil plus colloidal graphite over the plain oil it is 25 per cent. The mineral oil plus the necessary colloidal graphite (0.153 per cent colloidal graphite by weight) costs 35 cents. Assuming, as was done in the paper, the use of these oils on an automatic screw machine in which 1 gal of cutting fluid is added per hour, we have the values given in Table 1. The prices given in this table have been selected for comparison only and are subject to revision depending on quantity purchases.

TABLE 1 COMPARATIVE COSTS OF COLLOIDAL GRAPHITE, PLAIN OIL, AND SULPHURIZED OIL WHEN USED AS CUTTING FLUIDS

	Type of Oil		
	Plain	Sulphurized	Mineral plus colloidal graphite
Direct labor cost	$0.40	$0.40	$0.40
Total cost, material and grinding	0.20	0.20	0.20
Machine overhead	4.00	4.00	4.00
Cutting-fluid cost, plain oil	0.16	0.24	0.16
Colloidal graphite	...	...	0.19
Total cost	$4.76	$4.84	$4.95
Increased cost over that of plain oil	...	$0.08	$0.19
Increased cost over that of plain oil, per cent	...	1.68	3.90
Increased production over that of plain oil, per cent	...	12.00	25.00

The authors have indicated that they obtained better results with colloidal graphite in oil than when the graphite was suspended in water. The writer, however, would like to cite a very favorable report[5] on the use of colloidal graphite in water as a cutting lubricant which appeared in 1910. In this report it is said that colloidal graphite in water used as a cooling lubricant for die cutting of pipe threads enables the same to be done with one passage of the die instead of two, which was the custom

[3] Research Engineer, Cincinnati Milling Machine Company, Cincinnati, Ohio. Mem. A.S.M.E.

[4] Technical Director, Acheson Colloids Corporation, Port Huron, Mich.

[5] "Aquadag as a Lubricant," *Chemical and Metallurgical Engineering*, vol. 8, 1910, p. 293.

when using lard oil on this particular job. Furthermore, the threads cut with the colloidal graphite in water were shown to be cleaner and sharper.

This article[5] also reports that in a lathe operation comprising the cutting off of a large number of cold-rolled steel rods of 1 in. diameter, the number of cuts the tool made with one sharpening were 60 when using ordinary soap compound, whereas when using colloidal graphite in water the same tool made 980 cuts with only a single sharpening.

This article[5] and several instances on record have shown that there are times when colloidal graphite in water does a remarkably good job in increasing quality and production.

It might be well to emphasize the fact that colloidal electric-furnace graphite is abrasive-free, inert chemically, and of a particle size that makes it, for all practical purposes, the equivalent of a substance in true solution. Being inert it does not promote corrosion, nor is it altered by those influences which affect less stable substances. It would seem that colloidal graphite possesses many possibilities in the cutting-fluid field and that a wider practical use of the same in this connection is worthy of serious consideration.

E. M. Barber.[6] The writer believes that questions relating to the application of cutting fluids can be most advantageously answered and our knowledge of cutting-fluid performance developed into a practical basis for cutting-fluid specifications that will be of general practical value only through a program involving the following two fundamental steps: (1) Discovery and at least qualitative proof of the mechanism of cutting-fluid action; and (2) correlation of the case histories of individual tests in the light of this mechanism.

If this sort of a program is not carried out our knowledge of the performance of cutting fluids must remain that of a series of unrelated case histories. Thus, for example, we may learn that some particular cutting fluid is more efficacious than any other that we have tried when it is used on some particular job, but we do not know that it will be equally good on some other job. As a matter of fact, we strongly suspect that it will not, and the authors' tests with a constant area of cut but using a thick shallow chip and a thin deep cut confirm this suspicion. Even with this slight change, the order of rating of the oils was revised.

We must learn in a more general way, first, what are the properties of a good cutting fluid that make it a good cutting fluid and, second, to what extent are these properties desirable in cutting fluids for different applications?

The Texas Company has recently instigated a program of cutting-oil research, one phase of which involves the measurement of surface finish as a function of the cutting fluid and the cutting conditions. For the time being a lead abrasive method has been selected for the measurement of surface finish.

During the progress of this research a number of experiments have been performed to investigate various ideas of the action of a cutting fluid and the mechanism by which it functions. Following are a few selected examples of these tests.

1 It was suggested that the cutting fluid influences the finish of the work by controlling the friction and the back pressures between the chip and the tool, and that this hypothesis may be tested by experiments in which the friction on the top of the tool is deliberately increased and decreased over a considerable range.

To obtain variations in the friction between the chip and the tool, the rake of the tool was ground transverse to the length of the tool with wheels of varying grit. In preparing these tools the grinding wheel was not allowed to touch the cutting edge of the tool but was used merely to change the finish on the rake surface across which the chip must slide.

It was found that the friction between the chip and the tool had a very decided effect on surface finish; the higher the friction (rougher the rake surface) the rougher the surface of the finished work. A similar result was obtained when the chip clearance was restricted so that the chip could not flow freely away from the work.

2 It was also suggested that the cutting fluid reaches its position between the chip and the tool by flowing into a tiny crack that precedes the point of the tool. Thus, in addition to its ability to provide effective lubrication under extreme conditions of pressure and temperature, the oil must be able to penetrate well enough to get into a position to do its lubrication. It is believed that the penetrating ability of the oil is merely a matter of viscous flow into the crack under the pressure caused by the vacuum that is created when the work is fractured.

Thus, a curve of surface finish versus cutting speed would be expected to show a rather sudden deterioration in surface finish when the cutting speed becomes so high that the fluid is too viscous to flow into the crack fast enough to provide effective lubrication. This has been checked by running curves of surface finish versus cutting speed with oils of different viscosities. As the result it was found that for an oil of given viscosity there is a speed (feed, speed, material, and all other factors remaining constant) above which the oil no longer provides lubrication and that this speed varies directly as the fluidity of the cutting oil.

3 Another point that seems to follow from this conception of cutting-fluid action is that, all other conditions remaining constant, any one cutting fluid will maintain its effectiveness to a higher speed the narrower the cut. This occurred by virtue of the reduced length of the crack into which the fluid must flow in order to get between the chip and the tool. Tests were run to check this point and it was found that a given cutting fluid retained its effectiveness to a higher cutting speed with the narrow cut than with the wide cut.

There are many other factors concerned with the action of cutting fluids that have been or are under investigation as a part of our program; among the most important of these are the determination of that property by virtue of which a cutting fluid provides effective lubrication between the chip and the tool, and the reasons for variations in the effectiveness of different cutting fluids when used in different cutting processes.

It is interesting to note that many of the differences in tool life reported in the paper which cannot be accounted for by ordinary differences in the coolant action are explicable in terms of the foregoing conception of cutting-fluid action.

As one who is interested in experiments of the same sort as those outlined in this paper, the writer would like to ask the following questions:

1 What is the accuracy and reproducibility of the results? That is, how great were the variations in the 10 to 15 observations that were made on each point?

2 Were tool temperature measurements made concurrently with these tests? If so, was any correlation observed between cutting temperatures and tool life?

3 How was the sudden breakdown of the tool detected?

M. E. Lange.[7] Much laboratory work has been done in the machine field which deals with phases of metal cutting that are far removed from conditions actually encountered in metal-working shops. For instance, deep cuts are taken from test logs with heavy feeds, a condition found primarily when machining exceedingly large forged shafts. However, by far the largest number of

[6] The Texas Company, New York, N. Y.

[7] Engineer, Warner and Swasey Company, Cleveland, Ohio. Mem. A.S.M.E.

hours in industry are spent in finishing forgings or bars which are but little larger than the dimensions of the finished work.

Two conditions are generally encountered in production shops when taking roughing cuts. First, the chip generally is hardly more than from $^1/_8$ to $^1/_4$ in. deep. Second, scale is generally being cut at some part of the cutting edge. When cutting "black" steel with carbide tools for instance, the conditions of wear of the cutting edge are quite different from those found when cuts are taken on test logs without scale. This is true with tools of high-speed steel as well, although the difference is not quite as pronounced.

It would seem, therefore, in the first place, that tests for roughing cuts, to be of practical value to the major part of the metal-cutting industry, should be within the range of depths of cut mentioned by the writer and with such feeds as are practical on the average job. Second, it would be highly desirable to take all cuts on the outer or "black" surface of forgings or bar stock, or on the unmachined surfaces of castings so that true manufacturing conditions are being simulated. It would, of course, be expensive to use such material for test purposes only. However, by taking such test cuts on work which is borrowed for the purpose from regular production shops, it should be possible to approach true shop conditions without excessive material costs. In doing such work, either bar stock or forged units could be roughed out to within $^1/_{64}$ in. of final size to be refinished and sized by the owner after the material has been returned from the laboratory. Thus, there would be a reduction in manufacturing cost to the owner of such material which might make up in part at least for the added expense of handling and shipping.

The authors have confined their work, as reported in the paper, to speeds and feeds on the practical side, and therefore their findings should be a valuable and usable contribution to the art of metal cutting. It would have rendered their findings even more valuable if they had also confined themselves to the cutting of "black" stock. Perhaps this suggestion will help to keep future work of this nature on such a practical basis.

According to the authors' findings it would seem as if colloidal graphite could find a definite field of usefulness in the art of metal cutting. It is hoped that the oil companies will take this lead and will prove to the industry whether or not the added expense will be warranted. The authors point out that a more expensive fluid will readily pay for itself. Could Professor Boston show how the added expense of Oildag would be justified in a similar comparison?

The question of machine-tool lubrication is a vital one, and even though plain water might be the best cutting fluid under certain conditions, the damage done to the high-priced machine tool through corrosion and lack of lubrication would prohibit its use. The authors state that the superior soluble oil may at times not be used because it does not permit of adequate lubrication of an expensive machine tool. Would the addition of Oildag overcome this drawback? It would be of value to run wear tests simulating machine-tool conditions to determine the lubricating value of colloidal graphite in soluble oils.

A further question requiring an answer is whether the addition of colloidal graphite might not affect favorably the cutting of threads with taps and die heads where at present the heavy sulphurized-base oils are considered as being superior.

It would be helpful if there could be added below Table 3 a statement explaining such symbols as A-1-A or A-4-O.

O. L. Maag.[8] It is apparent from the data submitted in the paper that the cutting-fluid problem is more complex than one would think without intensive study. The fact that so many different fluids are used on the same type of product indicates that the type of cutting fluid to be used depends on such items as quantity and quality of work desired. The authors have summed the problem up quite well when they say: "Real economy lies in the selection of that cutting fluid which will do the job producing the best quality, the greatest production or both."

[8] Lubrication Engineer, The Timken Roller Bearing Company, Canton, Ohio.

Depending on whether a roughing job is being done or whether a close tolerance and good finish is desired, one fluid will show up better than another. As intimated, the type of steel also has an effect, and the writer believes that data on 4615, 52100, and 3312 S.A.E. steels should have been given in addition to the data on 2345 and 3140 S.A.E. steels, since they are largely used for such units as bearings and gears. Also, to cover the subject more completely, data on different tool steels should be developed. Likewise, it would be interesting to know the heat-treatment each of the steels machined received, since this factor will have much to do with the tool life, as well as the type of coolant used.

The writer's experience indicates that for close tolerances and good finish, oils are more desirable than water solutions. With oils there is no difficulty of sticking slides, the machines are kept tighter, and they run smoother and freer than when water preparations are used. Naturally, you do not obtain as much cooling as with water; however, this can be materially helped by the use of artificial cooling. It would be desirable if the authors could present data on the benefit of artificial cooling, holding the fluids to a definite temperature of approximately 80 F.

Data might well be made available on the film strengths of the compounded lubricants, since a number of companies are already standardizing their sulphurized and chlorinated cutting lubricants by checking them for film strength and holding this property to a definite figure. It is conceded quite generally that the good properties of this type of cutting fluid depend on its film strength, which may be determined on the Timken lubricant-testing apparatus.

Since straight chlorinated compounds of definite chemical structure are entering the cutting-oil field, it would be valuable to have data on such compounds as chlororetene, chloronaphthalene, chlorodiphenyl, and hexachlorethane.

The data given on colloidal graphite are quite interesting. Further, it is likely that they could be duplicated with other substances such as molybdenum sulphide, if there were a practical way of holding them in suspension. In plants where large amounts of cutting fluids are used, methods of reclaiming and reusing the coolants must be used for economic reasons. In service, oxidation products and acids are developed which tend to throw colloidal compounds out of balance, with the result that on settling or centrifuging, graphite and similar substances are separated from the cutting fluid. It is likely for this reason that such combinations have not worked out practically. The fact that the authors obtained only 3 per cent settling of graphite after the mineral oil and graphite had stood for three weeks can likely be accounted for by the absence of any petroleum acidity. If the oil had been used long enough to develop oxidation products as well as petroleum acidity before standing, the settling out would very likely have been much higher.

The writer believes that data such as obtained by the authors are quite valuable, and more should be obtained, so we may have a broader general knowledge of cutting and cooling compounds. However, due to such factors as individual operating conditions and local operating requirements, modification of any specific practice will frequently be found necessary.

B. E. Fleming.[9] The tests covered in the paper are confined as far as the writer can observe, to cutting operations with a straight turning tool, which might be comparable to a box-milling

[9] Lubrication Engineer, Shell Petroleum Corp., Milwaukee, Wis.

or cut-off job. It is known that this type of work comprises only a small percentage of automatic screw-machine, turret-lathe, and hand screw-machine work. The writer tried colloidal graphite on a Landis tangential die when cutting standard threads on wrought-iron pipe. The results were not as satisfactory from the standpoint of tool life or quality of thread as those obtained when using a blend of 15 per cent lard oil with 2 per cent added sulphur and mineral oil, which had a viscosity of 200 sec at 100 F.

The writer is obtaining excellent results with $1^3/_4$ per cent added sulphur to paraffinic oil of 150 sec viscosity at 100 F when this oil is used on general automatic screw-machine work cutting alloys of the following S.A.E. series: S.A.E. 3100 with .15 to .45 per cent carbon, S.A.E. 2300 with .15 to .45 per cent carbon, and S.A.E. 4100 and 4600 with .30 to .50 per cent carbon. The sulphur was added to the oil at a temperature high enough to keep it in suspension, but low enough to prevent discoloration. The finish blend is very agreeable to handle, it has no ill effects on the machine parts, and is hygienically ideal. This blend, will of course, discolor parts containing 30 per cent or more of copper. The writer finds that this blend has a decided advantage in that it facilitates inspection of the work during and after machining. It drains readily from the work and chips, thus favorably affecting oil consumption. However, such a material is not suitable for most broaching (draw), tough reaming, or thread chasing on soft tough metals. It seems that on such operations additional oiliness of the fixed oils is needed. Perhaps the authors can give reasons for this fact.

The writer would like to comment on the cost of the colloidal graphite used by the authors in their tests. Ordinary mined graphite is not suitable for use with cutting fluids. Is this not correct? The cost of good colloidal graphite is almost prohibitive when considered as a general cutting-oil compound in the shops where the writer is employed. The results would have to be very outstanding to warrant its consideration on even some of the most bothersome operations. From a practical point of view, most shops prefer to use the least possible number of cutting-oil blends, and some shops sacrifice on some operations in order to standardize and simplify cutting-oil requirements. This being the case it would be difficult to introduce special oils for some of the operations because it would be too expensive to use as a general cutting fluid.

The writer would also question the practicability of the colloidal graphite from the point of view of its performance in chip centrifuges and other reclamation devices. Judging by the behavior of such a blend during other experiments, it would seem that a great loss of the graphite constituent would occur during the reclaiming operations. This being true, the cost would be still further increased, and the concentration of the blend would be more or less questionable as more or less reclaimed oil was returned to service in the machines.

In machining alloy steels, the writer's attention has been attracted many times by the importance of the physical characteristics of the metal. It is of course true that cutting oils and coolants play a part that is too important to be overlooked in obtaining suitable tool life and finish; the condition of the metal is also a factor which must be considered if good ultimate results are to be obtained. The writer is of the opinion that there is some relation between the physical and chemical characteristics of the coolant or lubricant, and that to produce good cutting results the chemical and physical characteristics of the steel being machined must be considered. Heat-treatment to produce the proper grain structure, density, and suitable hardness of the steel being cut very probably has a definite effect upon its machinability.

The writer would be interested in learning of any tests of which the authors have knowledge which indicate the machinability of some alloys after heat-treatment. He would also be interested in what effect grain structure and physical condition of the steel have on its machinability and on the selection of the cutting fluid.

Maurice Reswick.[10] We in the oil industry, are deeply interested in the investigations of the A.S.M.E. Special Research Committee on Cutting Fluids. It helps us to visualize what the requirements of the industry are and points out the direction in which development of new products should be carried on.

From a practical standpoint, tool life is the most important factor in metal cutting. The failure of one tool on an automatic lathe results in delays which render ineffective the other tools on the same machine although they may still be in good cutting condition. Data on tool life versus cutting speed is therefore the most practical evaluation of cutting fluids.

The effect of colloidal graphite in cutting oils is of considerable significance. It appears that the introduction of solid particles of minute size in a mineral oil contributes to longer tool life and makes possible higher cutting speeds. Further investigations may disclose that other materials than graphite will give similar results provided such materials can be maintained in the oil in a condition approaching a colloidal suspension.

The presence of the solid particles in the colloidal suspension probably prevents metal-to-metal contact between the chip and the tool, acting as an antiweld medium. In other words, when the oil film breaks down under the pressure of the chip, the solid particles perform the function of preventing intimate contact.

The present tendency is toward transparent cutting oils, which facilitate inspection of the work while it is in the machine. Graphite has the disadvantage of rendering the cutting oil black in color and opaque.

Cutting oils compounded with animal fats and impregnated with sulphur are more chemically active than straight mineral oils. During continuous service and recirculation, it is possible that certain changes take place in the composition of the oil through the formation of iron soaps by interaction with the fats, and iron sulphides by interaction with sulphur. This brings up the question whether or not used cutting oils are more effective than fresh cutting oils.

Perhaps Professor Boston and his associates could give us some data at some future date on tool-life tests using an oil as received from the refinery and also on the same oil after it has been in service in regular production work for a reasonable period of time.

Authors' Closure

Many questions have been asked relating to the use or selection of cutting fluids. Some of these questions have reference to the practical application, while others suggest problems of research from which knowledge may be gained on the theory of cooling and lubrication. These questions are so extensive that a short supplementary bibliography on cutting fluids is appended to this closure for reference.

Mr. Adams presents a very interesting discussion relating to the functions of cutting fluids. From many experiments, as conducted by the authors, to determine whether a cutting fluid acts better as a coolant or lubricant, it is felt that cooling is of more importance than lubrication in the average metal-cutting operation, particularly in turning. In cutting ductile metals, a built-up edge is formed along the cutting edge of the tool over which the chip slides as it is separated from the work. This built-up edge is trapped in this position by force components which reach a magnitude of 300,000 lb per sq in. at a cut of, say, 0.025 in. feed. For lighter cuts, the pressure may reach 500,000 lb per sq in. It does not seem possible that a cutting fluid can penetrate between the chip and tool against such pressure. The

[10] Lubrication Engineer, Standard Oil Company of New Jersey, New York, N. Y. Mem. A.S.M.E.

fact that water, which is a better refrigerant than an oil, gives a higher cutting speed for any tool life than most oils, again would indicate that cooling is of most importance as far as tool life or tool wear is concerned. The authors have found that the tool life for a given cutting speed when turning a steel bar at different temperatures is greatest for the lowest temperature of the test log. These temperatures have been carried to 12 F below zero. The authors believe that the cooling of a tool by an air blast at different temperatures in order to eliminate lubrication would lead to similar results, but as yet they have not tried it. It would seem that lubrication at the low temperatures is not much different from that at the slightly higher temperatures, so that the results must be due to cooling. At the same time, it is recognized that lubrication is a variable factor in the problem.

In running drilling tests in which a hole of 1 in. diameter is drilled through a piece of steel in the form of a cube 1.5 in. on a side, in which the drill and work are submerged in a constant volume of liquid, the authors have been unable to find any appreciable or consistent difference in rise in temperature of the cutting fluid with different types of cutting fluids. The lubricant, although a poor coolant compared with water, may prevent the generation of heat, and therefore has less heat to absorb. Torque and thrust values at the point of the drill were also obtained, although the data have not been studied sufficiently to arrive at final conclusions. It would be expected that the lubricant producing the least torque and thrust, thereby doing the least work presumably because of lubrication, would produce the highest cutting speed for a given tool life. From one set of tool-life tests in turning steel, the authors have found that the tangential cutting force on the tool for a given group of cutting oils is directly proportional to the speed, that is, that cutting fluid which produces the lowest cutting force gives the lowest cutting speed for a given tool life, just the opposite of what might be expected.

The authors do not agree with Mr. Adams' description of tool failure. It appears from his question No. 4 that the tool in turning steel fails by becoming dull on the cutting edge. Actually, it is the cutting edge that is the last thing to fail at the time breakdown occurs. Further, the generation of heat between the tool and work is greatest at the beginning of the cut when the tool is sharpest. As the tool is cupped on its face by the abrasive chip, the cutting force and temperature are reduced and both become a minimum just before the breaking off of the acute cutting edge formed by the tool flank and groove.

Mr. Adams' summarized suggestions are excellent. Some of these have been carried out, but unfortunately the results, as have been outlined previously in this closure, do not fall in altogether with the logic. Therefore, it appears that still more work must be done before a complete understanding of cutting fluids is gained and it becomes possible to specify the theoretically correct cutting fluid for each class of work.

Mr. Ernst's discussion as to the use of cutting fluids and their action on chip formation is in agreement with the authors' opinions. However, confirming laboratory or practical tests are still lacking to give us a complete understanding of the subject. The authors have found that, if a good machined finish is desired, the built-up edge should be made small. This is accomplished singly or jointly by taking a light cut, operating at high speed, using a tool having considerable rake, and applying the correct type of cutting fluid. However, the authors believe that the influence of speed in many cases overshadows all of the others.

Mr. Szymanowitz has presented the subject of cost in an interesting light, showing that the cost of a cutting fluid may be increased appreciably and yet, considering all of the equipment involved in the operation, the total increased cost in per cent is small in comparison with the increased production.

It is interesting to note, as indicated by Mr. Barber, that some manufacturers of cutting oils are carrying on fundamental research in the use and action of cutting fluids. Reference is made in his second example to the flowing of the cutting fluid into the tiny crack preceding the cutting edge of the tool. Actually, when cutting ductile metals, the authors believe that there is no crack preceding the point of the tool, inasmuch as this space is filled with the built-up edge under tremendous pressure. The results of his tests on surface finish are extremely interesting. It is difficult, however, to understand that surface finish is not better at the very high speeds in spite of any cutting fluid used. Mr. Barber also brings out the important point that the performance of cutting fluids will vary with the type of process involved. Mr. Barber's three questions may be answered as follows:

1 Most of the experimental points representing cutting speed and tool life for a uniform test log and well-prepared tools fall within the thickness of a line. Frequently, at the beginning of tests some tool bits are found to give consistently high or low results, in which case they are discarded. Also, some cutting fluids have been found to give more consistent or uniform experimental data than others.

2 Tool temperature measurements were not made concurrently with the tests discussed in the paper. They have been made, however, in other tests by the authors. A very definite correlation is observed between cutting temperatures and tool life. The higher the cutting speed, the higher the cutting temperature and the shorter the tool life. The authors have considerable data showing the relation between the cutting force, temperature, and tool life in turning steel, in which the toolwork thermocouple was used. One paper was presented at the Annual Meeting of the A.S.M.E. in December, 1934, but was not published. At this time additional work is being done along this line in which a thermocouple tool is being used to measure temperatures when cutting different materials or when cutting one material with various cutting fluids. These data are not yet ready for publication.

3 The method of determining tool breakdown has been described in an article on "Machinability of Steel" in the National Metals Handbook, 1936 edition. It was described further in another paper[11] by the authors. This paper[11] describes a preliminary and final tool breakdown. The preliminary tool breakdown, which occurs sometimes soon after starting the cut, involves the breaking off of one part of the cutting edge before the cupping has proceeded far enough to cause a general breakdown.

Preliminary tool failure may or may not cause a change in the finish on the work or a change in size of the work. It is manifest either by a burnished ridge on the shoulder of the cut or by a change in surface finish or both. The final breakdown is detected either by an increase in cutting force on a dynamometer or power on a wattmeter, or by the presence of a burnished surface on the shoulder of the cut. One skilled in running tests of this nature can, by watching the chips come from the work, tell amost exactly when the tool fails. In many tests the authors have found that the data from preliminary tool failures change only the constant C in the equation $VT^n = C$.

Mr. Lange has sounded the note of practical-versus-laboratory investigations in metal cutting. He points out how true manufacturing conditions may be simulated in the laboratory by taking one cut from black-surface forgings, after which the forgings could be returned to the manufacturers. This might be practical in a city such as Cleveland where schools are located close to industry. However, in Ann Arbor the situation is somewhat different. In turning forgings, the work would not always run

[11] "A Study of Cutting Fluids Applied to the Turning of Monel Metal," by O. W. Boston and W. W. Gilbert, Trans. A.S.M.E., vol. 158, November, 1936, paper MSP-58-10, pp. 685–695.

true and, therefore, there would be a variation in depth of cut. It would seem, however, that work of this nature could be done best by careful observation in the manufacturing plant.

Mr. Lange further points out that the paper indicates the possibility of using to advantage colloidal graphite in commercial cutting fluids. It was not the authors' intention in presenting these data to promote the use of colloidal graphite as an ingredient of commercial cutting fluids, but rather to show some results of its use. Inasmuch as these results show superior performance, it is felt that it would be quite possible to prepare cutting fluids containing colloidal graphite which could be adapted to various processes and metals and show profits in spite of the high cost of graphite. Mr. Szymanowitz gives, in his discussion, data on the cost when using the expensive graphite. It is seen that, even with the high cost of graphite, the total cost over that when plain oil is used is only 3 per cent with an increase in production of over 25 per cent, whereas the sulphurized mineral oil shows an increase of 1.68 per cent in total cost over plain oil with an increase in production of 12 per cent.

Since this paper was presented, the authors know of numerous cases where colloidal graphite has been tried out on commercial work. Some of these instances have resulted in failure, inasmuch as the cutting fluid has not been adapted to the colloidal graphite, or the resulting mixture to the work. Undoubtedly there are numerous difficulties of a chemical and mechanical nature to be overcome in applying colloidal graphited cutting fluids commercially. However, the authors believe that these can be overcome.

Mr. Maag raises the question as to the use of colloidal graphite in various oils. Petroleum acidity will develop as the oil is used, and presumably will cause the colloidal graphite to settle out. This point also has been raised by Mr. Reswick and was discussed verbally by Mr. Oldacre[12] at the time of the meeting. It is pointed out in the paper that the colloidal graphite did not function satisfactorily in two of the three emulsions used. This in itself indicates the need for a correct type of soluble oil to carry the colloidal graphite, should it be used.

Mr. Fleming raises the question as to the practicability of using colloidal graphite because of its performance in chip centrifuges and other reclamation devices. Undoubtedly, the cutting fluid should be analyzed frequently in order that the graphite content be maintained above the minimum value found useful. Mr. Fleming also raises the question as to the relation between the physical and chemical characteristics of the cutting fluid and that of the physical and chemical characteristics of the steel being machined. This is a subject deserving a great deal of attention. Much is being done along this line at the present time. Inasmuch as the paper does not include this wide field for discussion, it is felt that the present space should not be covered by such a lengthy discussion. Many articles have been published on this subject, and the authors refer to (1) and (4) in the Bibliography at the end of this closure.

Mr. Reswick raises several additional questions, one of which involves the performance of a new oil as compared with the same oil after being used for some time. In order to avoid the possibility of error, the authors have constantly used fresh oils in their tests. It has been found true that as the oils change or develop acids their performance will be different.

Undoubtedly, the authors have not answered all questions that have been raised. Inasmuch as they are almost constantly engaged in experimental work with cutting fluids, they would be very happy to have any one interested communicate further with them.

[12] W. H. Oldacre, Director of Research, D. A. Stuart & Company, Ltd., New York N. Y.

BIBLIOGRAPHY

1 "Utilization of Proper Cutting Fluids Will Pave the Way to Ecomomy in Production," by Joseph Geschelin, *Automotive Industries*, vol. 64, February 14, 1931, p. 228.

2 "Extreme Variation in Cutting Fluid Practice Brought Out by Survey," by Joseph Geschelin, *Automotive Industries*, vol. 64, May 2, 1931, p. 668.

3 "Choice of Cutting Fluids Simplified by Research," by Joseph Geschelin, *Automotive Industries*, vol. 67, July 9, 1932, p. 36.

4 "Bibliography on the Cutting of Metals," by O. W. Boston, A.S.M.E., 29 West 39th Street, New York, N. Y., 1930.

5 "A Bibliography on the Cutting of Metals, Part II," by O. W. Boston, published by O. W. Boston, University of Michigan, Ann Arbor, Mich., 1935.

6 "Engineering Shop Practice," by O. W. Boston, John Wiley & Sons, Inc., New York, N. Y., vol 1, 1933, and vol. 2, 1935.

Equipment and Problems in Handling Oil as a Locomotive Fuel[1]

M. A. Herzog.[2] The writer was interested particularly in the author's presentation of the evils of open steaming for heating fuel oil, and his emphasis on the harmful effects of water in oil. This is a phase of fuel-oil handling which has been neglected too much by many practical railroad men. Locomotive oil tanks on the St. Louis-San Francisco Railway are equipped with both open and closed heaters, and the engine crew is instructed to use the open heater only to break up any accumulation of sludge or sediment on the bottom of the tank which might interfere with the free flow of oil to the burners. In spite of this it is quite usual to find from 5 to 8 per cent of water in samples taken from locomotive oil tanks. In cases of steam failures blamed by engine crews on poor oil, investigation has shown that the oil contained from 20 to 30 per cent water. This water was introduced from heaters either in the terminal fuel-oil storage tanks or in the locomotive tank. No evidence has ever been found of fuel oil being shipped by the refiners with more than a trace of water.

The presence of water in fuel oil not only reduces the heat content proportionately, but as stated by the author it also results in loss of combustion efficiency and may cause serious difficulties due to increase in viscosity and foaming of the oil when heated. It is generally believed that water in heavy fuel oil will settle to the bottom when the oil stands undisturbed, and can then be drawn off. With most fuel oils, this is far from true. Water introduced into fuel oil by the condensation of steam from a heater will usually form a permanent emulsion with the oil, and will separate only slightly or not at all after days and weeks of standing. The writer has seen such emulsions which contained over 50 per cent water, and which did not separate appreciably after standing for more than a month. This reluctance of water to separate is aggravated by the low gravity of present-day fuel oil, much of which is of practically the same weight as water, so that there is no tendency for the water to settle out.

Water in locomotive fuel oil is definitely harmful, and since it cannot be removed after it is in the oil, the only remedy is to keep it out. This can be done by eliminating open steaming and providing ample closed-heater capacity, with possibly some mechanical device for agitating the oil to prevent accumulation of sediment. It is probable that if water were kept out of the oil, bottom sediment and sludge accumulation would be negligible.

Elimination of open steaming means that during cold months heavy fuel oil must be shipped in tank cars equipped with closed heaters in good condition. An increasing number of fuel-oil tank cars are being so equipped, but it is still all too usual to receive fuel oil in cars not provided with steam coils or with the

[1] Published as paper RR-58-2, by Guy M. Bean, in the August, 1936, issue of the A.S.M.E. Transactions.

[2] Chief Chemist, St. Louis-San Francisco Railway, Springfield, Mo.

coils leaking badly. In either case, it is impossible to unload a viscous oil without first mixing it with a considerable amount of water in the course of heating. Refiners should realize that shipment of fuel oil in such cars is causing the railroads considerable trouble and extra expense in cold weather.

J. C. Martin, Jr.[3] The oil-burning locomotive of today is practically the same as it was 25 years ago, with the exception of one principal change, namely the method of firing, whereby the burner was taken from the rear of the firebox and situated at the front or flue-sheet end so that the injected fuel could be discharged in a direction opposed to the draft. Today, and for the past 20 years, this has been standard practice; but outside of this highly beneficial change, which saved fireboxes from the punishment of localized heat, no other than minor changes have been made in the equipment, furnace design, or drafting of an oil-burning locomotive.

The firebox of a locomotive, even in the largest types, presents a very restricted space in which to burn a gaseous fuel, such as atomized fuel oil. Because of this fact, and because intermittent conditions from maximum to minimum firing rates often change within a relatively few minutes, ways and means must be devised to burn the fuel in the most efficient manner. When it is considered that the fuel oil must be burned in the modern wide-firebox engine at the rate of from 10 to 12 gpm, and preferably with a single fuel-oil burner to avoid complications in equipment, some idea can be had by combustion engineers not specializing in locomotive boilers as to the exacting conditions obtaining.

Although the present practices of burning fuel oil in a locomotive firebox have proved to be reliable these many years and capable of getting locomotives over the road expeditiously, constructive criticism is always in order, and to this end the writer's remarks are directed.

A major item that demands attention is the character of the fuel oil now available and to be furnished by the refineries in the immediately following years. Present facilities on locomotives and at terminals have not been brought in line to meet the changed complex of the present-day cracked fuel oils. The railroads have not yet sensed to a sufficient degree the fact that changes must be made if the maximum efficiency is to be obtained from cracked fuel oil for steam-generating purposes.

There is nothing particularly unusual about the problem. All combustion engineers are fully aware of the fact that these cracked fuels must be broken up or pulverized, so to speak, so that they will present the greatest possible carbon content for oxidation by the air introduced into the firebox for combustion purposes. The logical thing to do in effecting this is to provide adequate heating of these cracked oils. This should be done at three points. First, they should be heated to approximately 90 F to permit them to flow freely to the fuel-filling cranes and into the locomotive tank. Second, they should be heated to approximately 120 F in the locomotive tank so that they will flow freely through flexible conduits and pipe connections to the locomotive side in sufficient volume to meet maximum firing rates. Third, they should then be heated at the locomotive side with the most efficient type of heating device possible so that it will leave the heater and pass to the burner at a temperature of not less than 200 F. This would mean a temperature at the burner point of not less than 190 F.

Present facilities for heating fuel oil on locomotives provide only the handed-down practice of a so-called superheater comprised of a $3^1/_2$-in. steam pipe 5 to 7 ft long jacketing the fuel-oil pipe to the burner. This was sufficient for top fuel oils, but is now inadequate with cracked fuel oils. What is needed is a heating facility capable of maintaining, without question, a higher temperature of the oil at the burner.

[3] Consulting Engineer, Combustion and Refractories, Los Angeles, Calif. Mem. A.S.M.E.

In regard to the temperature of the oil, this obviously should be varied to suit the character of the cracked fuel being received, particularly its flash point. Live steam for heating is advocated on account of its heat-exchange value as compared to the relatively low head with which the fuel oil flows from tank to burner by gravity.

It may be stated with certainty that, with economy of steam for heating considered and with a well-designed heat exchanger located in the same position on the locomotive as the present superheater, the temperature of the oil may be raised from the proposed minimum of 200 F to a temperature even 100 deg higher (flash point permitting) without any possibility of volatile constituents of the cracked fuel being lost. This higher temperature could be attained because the cracked fuel is usually boiled off in the refinery at temperatures far in excess of 300 F, that is, it was produced at temperatures varying from 600 to 800 F.

Another item of consequence to be considered in meeting the characteristics of the present cracked fuel oil is the adaptation of pressure on the oil to the burner. This should now be considered seriously since it would result in constant control of the fuel and uniform flow through the burner, and therefore aid greatly in the efficiency of combustion over the present gravity feed. This has not been done heretofore because of complication of equipment, lack of space, and no crying need until cracked oil took its place as fuel. With the advent of cracked fuel consideration should be given to the production of a simple system with a pressure-fired oil burner as a constructive improvement over the present gravity system of firing.

Steam-jet atomization for burners may well be continued as heretofore; but with a pressure burner in lieu of the present gravity-type burner the steam consumption for atomization will be materially reduced. Established practices show a steam consumption of 3 per cent for pressure burners as against a steam consumption of from 5 to 8 per cent with present standard locomotive gravity burners such as the Booth or Von Boden type, which are representative.

Mechanical atomization of fuel oil into locomotive fireboxes is yet a problem to be reckoned with. Tests along this line have proved to be disappointing, due to the delicacy of the apparatus, carbonizing of burners, and inability to maintain maximum rates of firing required with a single burner.

Reliability of apparatus is of paramount importance, and much research work must yet be done to make mechanical atomizing on a locomotive a success. However, there will always be a reward for effecting the successful mechanical atomization of fuel oil in a locomotive firebox, due to the elimination of steam as an atomizing element, as well as in increasing the volume of the firebox as a combustion chamber in which to burn gaseous-type fuel; for it will be clear to those concerned in this problem that the steam for atomizing is a noncombustible ga soccupying space in the firebox which could otherwise be utilized for increasing thermal efficiency.

Author's Closure

Mr. Herzog's comments on the importance of providing transportation, terminal, and locomotive fuel-oil-handling facilities that will preclude contamination of the fuel through the admixture of water are timely and accord fully with the author's ideas. These phases of fuel-oil handling are all too frequently overlooked and result in efficiency losses that aggregate to considerable amounts.

Too much stress cannot be placed on the need for careful study of all apparatus involved so that the fuel may be delivered to the locomotive furnace in the most suitable condition for

proper functioning, which means as free from moisture as is practically possible and at temperatures required for efficient firing.

While the higher percentages of water in fuel oil as quoted by Mr. Herzog are rather exceptional, the fact that they are encountered only stresses the importance of keeping them to a minimum. Properly designed indirect heaters can be provided in all heating phases that will suitably heat the fuel to the temperature required in each phase and their adoption will readily repay the involved cost in final efficiencies.

Mr. Martin's discussion fully bears out the author's idea both as to the need for providing means for separate heating of the fuel in the locomotive reservoir and final heating of the fuel to burning temperatures on the locomotive side.

There seems to be a definite lack of understanding, among many who are daily handling modern locomotive fuel oils concerning the great change in the fuel characteristics that have been brought about through modern refinery practices. It is important that every consideration be given to the needs for equipment changes that will meet these fuel changes. This involves study and experimentation with all heating problems, methods of delivery of the fuel to the burner, types of burners that will give the best atomization of the fuel, and finally careful proportioning and location of air-admission openings in the furnace.

Functions for Solution of Three-Moment Equation for Beam Columns With Nonuniform Loads[1]

H. M. Hansen.[2] The paper represents a convenient supplementary contribution to existing tables which, for different types of end conditions, transverse elementary and total loadings, give the influence on the slope at the end of an assumed simply supported beam with constant flexural rigidity. Since the author has computed the table on the basis of well-known theories and formulas in common use, the writer's discussion will be confined to the errors introduced by the substitution of an elementary concentrated load for a distributed load, when the element used is one tenth of the length of the span.

Using the same symbols as in the paper, we have

$$\psi_C = \frac{6}{(jL)^2}\left[\frac{\sin KjL}{\sin jL} - K\right] \ldots\ldots\ldots\ldots [1]$$

as the combined effect of an axial and a transverse concentrated load. By an integration it will be found that the function for a load, uniformly distributed over a distance $2CL$, can be written as

$$\psi_D = \frac{6}{(jL)^2}\left[\frac{\sin KjL}{\sin jL}\,\frac{\sin CjL}{CjL} - K\right] \ldots\ldots\ldots [2]$$

in which KL is the distance to the center of distribution. For a distribution of one tenth of the span, or $C = 1/20$

$$\psi_D = \frac{6}{(jL)^2}\left[\frac{\sin KjL}{\sin jL}\,\frac{\sin (jL/20)}{(jL/20)} - K \ldots\ldots [2a]\right.$$

The value of the distribution factor $(20/jL) \sin (jL/20)$, between $jL = 0$ and the critical condition $jL = \pi$, varies from unity to 0.9957. The error due to the substitution of a concentrated load for a uniformly distributed load is therefore, in this case, small and can be neglected for ordinary purposes.

TABLE 1 PER CENT DIFFERENCE[a] BETWEEN ψ_C AND ψ_D

jL	Per cent difference when $K = 0.1$	$K = 0.5$	$K = 0.9$
0	+0.25	+0.33	+1.32
1	+0.26	+0.34	+1.24
2	+0.29	+0.35	+1.00
3	+0.38	+0.39	+0.51

[a] Per cent difference = $100\,[1 - (\psi_D/\psi_C)]$.

Table 1 of this discussion gives for various values of K and jL the difference in per cent between function ψ_C, the tabulated value, and ψ_D from Equation [2a].

The effect of a load gradient on the elementary function ψ can in part be investigated by considering a trapezoidal loading, the exact expression for which can be shown to be

$$\psi_T = \frac{6}{(jL)^2}\left[\frac{\sin KjL}{\sin jL}\,\frac{\sin CjL}{CjL}\left\{1 + \frac{3(G-K)}{C}\cot KjL\left(\frac{1}{CjL} - \cot CjL\right)\right\} - G\right] \ldots\ldots\ldots [3]$$

where, as before, $2CL$ represents the distribution, KL is the distance to the center of distribution, and GL is the distance to the center of gravity of the load; GL and KL are measured from the same support and have the same positive direction. Analytically

$$G = K + \frac{C}{3}\,\frac{p_1 - p_2}{p_1 + p_2}$$

where p_1 and p_2 are the intensity of loading at the ends of the trapezoid.

If investigating one of the more extreme cases such as a triangular loading, Equation [3] reduces to

$$\psi_\Delta = \frac{6}{(jL)^2}\left[\frac{\sin KjL}{\sin jL}\,\frac{\sin CjL}{CjL}\left\{1 \pm \cot KjL\left(\frac{1}{CjL} - \cot CjL\right)\right\} - \left(K \pm \frac{C}{3}\right)\right] \ldots\ldots\ldots [3a]$$

where the upper sign is used for $G > K$, the lower for $G < K$. The gradient factor may be given a more convenient form by substituting for $\cot CjL$ the first three terms of its series, and the equation can, for all practical purposes, be written

$$\psi_\Delta = \frac{6}{(jL)^2}\left[\frac{\sin KjL}{\sin jL}\,\frac{\sin CjL}{CjL}\left\{1 \pm \frac{CjL}{3}\left(1 + \frac{(CjL)^2}{15}\right)\cot KjL\right\} - \left(K \pm \frac{C}{3}\right)\right] \ldots\ldots\ldots [3b]$$

In this case, where $C = 1/20$, the first two terms will suffice and the equation takes the particular form

$$\psi_\Delta = \frac{6}{(jL)^2}\left[\frac{\sin KjL}{\sin jL}\,\frac{\sin (jL/20)}{(jL/20)}\left(1 \pm \frac{jL}{60}\cos KjL\right) - \left(K \pm \frac{1}{60}\right)\right] \ldots\ldots\ldots [3c]$$

Applying this Equation [3c] to different values of K and jL, the per cent difference between ψ_c, the tabulated value, and ψ_Δ from Equation [3c] is shown in Table 2 of this discussion. While the elementary errors under certain extreme conditions are rather high, as shown by Table 2, the error occurring from the use of the author's tables on a triangular loading over one half end of the beam amounts to 0.3 per cent of the theoretical value.

[1] Published as paper AER-58-6, by John E. Younger, in the August, 1936, issue of the A.S.M.E. Transactions.

[2] Assistant Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Mich.

TABLE 2 PER CENT DIFFERENCE[a] BETWEEN ψ_C AND ψ_D

jL	Per cent difference when $K = 0.1$		$K = 0.5$		$K = 0.9$	
	$G>K$	$G<K$	$G>K$	$G<K$	$G>K$	$G<K$
0	—16.1	+16.6	—0.8	+1.4	+16.3	—12.0
3	—15.7	+16.5	—0.3	+0.5	+16.3	—15.3

[a] Per cent difference = $100\ [1 - (\psi\Delta/\psi C)]$.

For any distributed loading usually encountered in practice it seems, therefore, reasonable to expect that the use of the author's tables will give results which are consistent with the usual expected accuracy of other required data.

On the other hand, the results so obtained can, in most cases, be expected to vary about 0.5 per cent with the theoretical value. It seems, therefore, not justified to use more than three significant figures in the author's tables.

Welding Heavy Machinery[1]

F. O. Leitzell.[2] The authors have presented the problems encountered in the proper production of heavy welded machinery in a clear, concise, and excellent manner. Too many times the problem of designing welded machinery has been approached without the proper thought being given to the advantages and higher efficiencies obtainable from welded construction. Many designs have been made by simply replacing welds for rivets and bolts or cast construction, with no consideration given to weight saving or proper design. The authors have pointed out clearly that to obtain full advantage of welded construction one must take into account the shortcomings of riveted and cast construction, and be able to substitute therefor welded constructior where it can be applied with greatest advantage. Welding is not a cure-all, and the authors recognize this fact. However, there are a few points in the paper which can be stressed by additional discussion.

It is true that thick and thin members can be welded together and various metals can be combined in one piece by welding, but when this is done care must be used so that undue warpage will not occur, due to welding or to final stress relieving if this is necessary. The authors have mentioned that different metals may be welded together providing their coefficients of expansion are sufficiently similar so that undue stress is not set up when the welds cool.

In regard to the peening of welds in the construction of welded machinery, the writer believes that there are many places where it is advantageous to peen the various layers of weld, not to hide porosity or other defects, but for the proper working of the metal. This is especially true where extremely heavy sections are welded to light sections. Stresses are set up in this case and peening is a decided advantage. In other cases, light peening of the various layers removes scale and slag and leaves a clean surface for the succeeding bead. Furthermore, peening has a tendency to decrease warpage regardless of whether or not the finished piece is stress relieved by heating.

The authors' discussion of stress relieving by heating is excellent. The results required of welded machinery are so different from pressure vessels that the writer agrees with the authors when they state that no definite hard and fast rules of procedure can be laid down. However, the results desired in either case are the same, that is, a soft ductile weld with as nearly the same properties of the parent metal as it is possible to obtain. Where the various parts are of different thicknesses, the process of heating and cooling can be set only from experience in order to obtain ductile welds with a minimum of warpage.

[1] Published as paper MSP-58-5, by C. A. Wills and F. L. Lindemuth, in the October, 1936, issue of the A.S.M.E. Transactions.

[2] Vice-President, Lewis Foundry and Machine Company, Pittsburgh, Pa. Mem. A.S.M.E.

The Electric Welding of Monel and Nickel[1]

P. R. Kosting.[2] The writer wishes to take exception to one statement made by the authors. This statement, found at the end of the first paragraph under the subtitle "Quality and Physical Properties of Deposited Metal" concludes with the phrase: ". . . . . . yield strengths of welded joints are still of little value, except when all-weld-metal specimens are used."

The engineer of today is using as the basis for his calculations, yield-strength values to a greater extent than his predecessors. This is particularly fortunate in the case of the common nonferrous alloys, the yield strength of which can be varied to a much greater extent than the tensile strength by combinations of cold working and annealing.

In the case of monel-metal plate, tensile strength is lowered less than 8 per cent by controlled annealing, while yield strength 0.00 per cent set (P.L.) is lowered 40 per cent. When welding monel there is an annealing effect adjacent to the weld. This heat-affected zone does have considerable influence on the properties of the welded joint. Indications are that the greater the electrical energy used in the arc for satisfactory welding, the less the number of layers of weld metal required and the lower the strength of the weld. The technique of determining yield strength of nonhomogeneous materials such as welded joints is not yet satisfactorily worked out. Using specimens that permit true axial loading and using sensitive extensometers, yield strength 0.00 per cent set (P.L.) of joints can be varied 30 per cent approximately without affecting tensile strength when specially annealed. It is therefore necessary to measure yield strength, especially for sets of lower percentages in order to follow the effects of varied manipulations. When using welded nonferrous metals the yield strength is very important.

Author's Closure

The authors agree with Dr. Kosting on the point he raises that yield strengths are being used more widely in machine-design calculation. There is, however, no full agreement on what a yield point is, for it is necessary to indicate the per cent set at which the yield point is taken, i.e., 0.00 per cent, 0.05 per cent 0.2 per cent, 0.5 per cent, or 0.75 per cent set.

American Hydraulic-Laboratory Practice[1]

Robert W. Angus.[2] The author has given an all too brief review of the hydraulic laboratories and hydraulic-laboratory practice in America. So far as the writer knows, he is the first Freeman Scholar to spend his entire time on this continent and he has used it very profitably. What Dr. Freeman did for Europe in his "Hydraulic Laboratory Practice," Mr. Hooper has done for America on a much smaller scale.

Some omissions are bound to occur and this is true regarding the laboratories for studying pumps, as these are fairly numerous. The author does not mention the new pump laboratory of the Dominion Engineering Works in Montreal, which has done some useful experimental work.

[1] Published as paper MSP-58-7, by F. G. Flocke and J. G. Schoener, in the October, 1936, issue of the A.S.M.E. Transactions.

[2] Chemical Engineer, Watertown Arsenal, Ordnance Department, U. S. Army, Watertown, Mass.

[1] Published as paper HYD-58-3, by Leslie J. Hooper, in the October, 1936, issue of the A.S.M.E. Transactions.

[2] Professor of Mechanical Engineering, University of Toronto, Toronto, Ontario, Can. Mem. A.S.M.E.

For turbine testing, and river and hydraulic structures, a laboratory located on a natural stream has many advantages, particularly in the way of having the water in a calm state as compared with that from pumps which cause turbulence that is hard to damp out; the laboratory at Worcester is an example of the former.

The turbine-testing laboratories are all rather similar and the large volume of water used by the one at Newport News shows that the scale for the models need not be small. The writer has considerable experience with centrifugal pumps, most of which are run for test before being delivered; the smaller ones usually under the full-scale conditions, and the larger ones at reduced speed. In many cases the writer has found the test-floor results materially different from those on the installed unit, and as the shop tests were known to be accurate, it would appear that the characteristics of the pumps are very easily affected by the setting. Therefore, too much care cannot be used in duplicating the actual setting in the laboratories.

Duplicate pumps made at the same time in the same shop rarely have exactly the same characteristics, and there still appears to be a margin between the actual and predicted pump results that cannot be overcome by adjustable vanes, as in the turbine.

In view of the extensive notice given to cavitation testing, further comment here is unnecessary, but the writer was greatly interested, when he visited Sweden in 1935, to know that in one shop at least, cavitation runs were made on all model runners of new design, and the plants for which the turbines were being made were designed on the basis of the cavitation tests. The cavitation-research field has apparently only just been entered.

The glass trough is invaluable for open flow work. Last winter, at the University of Toronto, an extensive study was made, under the writer's direction, of the flow over a model of the dam at Abitibi Canyon in northern Ontario, and in the only data available from the power plant, the experiments corresponded remarkably well with the measured results at the dam. Such work is invaluable and gives accurate data for the designer.

The writer believes that where a river model has different scales for length, width, and depth, as in the case cited at Carnegie Institute of Technology, the interpretation of the results leaves room for much question. Two different scales are troublesome enough, but the third greatly increases the difficulties. The use of transverse metal fins to vary Kutter's n is unusual and would seem to change the flow conditions greatly, even though it produced the desired mean hydraulic gradient. The model should be a true copy of the prototype, the resistance being produced in exactly the same way in both, if the stream flows are to be comparable.

The author's statement as to the tendency to reduce the scale ratios by increasing the model sizes is interesting. Some years ago the writer asked a distinguished German experimenter what scales should be adopted in river flow work, and the surprising reply was, "Full size;" that is, the factors for reducing the model results are not, in his opinion, as definite as is desirable in this class of experiment. On the other hand, small-scale model turbines produce with remarkable fidelity, curves of efficiency, output, and speed which enable results on the prototype to be predicted accurately.

Author's Closure

The comments and additions by Professor Angus in regard to centrifugal pumps and laboratories devoted to their test are appreciated. In this connection it should be noted that Table 3 of the original article should be amended to indicate that pump testing was also being done at Cornell University. This type of work was found in progress there but mention of it was omitted accidentally.

The author desires to take this opportunity to thank the directors of the various laboratories visited. Their kindness and cooperation during the inspection trip were appreciated.

Fuel Panel Discussion on Cinder Catchers

At the Annual Meeting in December, 1936, papers dealing with various phases of the fly-ash and flue-dust problem were presented by ten authors. These covered methods for measuring the quantity of entrained dust in flue gases, types of apparatus for removing solid matter from flue gases before their discharge to the atmosphere, utilization of pulverized-fuel fly ash as aggregate for a new kind of concrete and the manufacture of a building block, and the cinder and fly-ash public nuisance. P. H. Hardie describes measurement methods that are applicable to different types of dust-separating devices. Apparatus described and the authors of the various papers are: Gas-scrubber installation at a plant of The Edison Electric Illuminating Company of Boston, M. D. Engle; spray-zone fly-ash eliminator at the New York Edison Company's Hell Gate Station, J. J. Grob; a device utilizing directional changes of flow in a fan impeller to separate dust from flue gases, H. F. Hagen; a scrubber that causes ash particles to impinge on wetted vertical carbon plates as the gas travels in a staggered path through the device, O. Craig; cleaning flue gases by electrical precipitation, C. W. Hedburg; a combination recirculator and controlled multicyclone, L. C. Whitton, Jr.; and a compound type of dust eliminator utilizing a concentrating chamber and a cyclone, S. Brown. J. R. James outlines the use of fly ash and crushed cinders as concrete aggregate by The Detroit Edison Company and of fly ash in manufacturing building blocks. W. G. Christy emphasizes the fact that the discharge of solids from stacks has greatly increased of late and that the public is demanding action.

Résumé of Methods for Measuring Flue Dust

By P. H. HARDIE,[1] BROOKLYN, N. Y.

EXTENSIVE development work on methods for measuring the quantity of entrained flue dust[2] in the gases of coal-fired plants has been reported by a number of authors. Many different types of apparatus, employing slightly different test procedures, have been tried. As yet, none of them has been approved by the A.S.M.E. Power Test Codes Committee on Dust Separating Apparatus, nor is any standard generally recognized.

This paper will discuss the more general types of apparatus with special reference to their application and limitations. No attempt will be made, however, to cover devices for measuring atmospheric dust pollution, such as the U. S. Public Health Service Empinger, Owens Jet Dust Counter, and Drinker Electric Precipitator. This phase of the subject is adequately covered in the U. S. Public Health Bulletin No.2 17, published in 1935.

Dust Measuring a Sampling Process

Due to the large volume of gas involved, the problem of measuring flue dust has resolved itself into a sampling process. The following important principles of sampling are recognized as necessary in order to obtain reliable results. First, samples must be taken from a sufficient number of points in the cross-section of a flue to represent the entire flow. Stern (1)[3] says that a point at which the average conditions prevail can be determined, and only a few samples need then be collected. Second, the samples must be withdrawn from the main stream without change in composition. Third, the dust must be separated without loss or contamination. Fourth, the size of samples withdrawn must be sufficient to permit determining the weight of the dust collected with reasonable precision, and the per cent of combustible and size analysis if these data are also objects of the test. Fifth, supporting data must be taken to permit weight averaging of the individual samples.

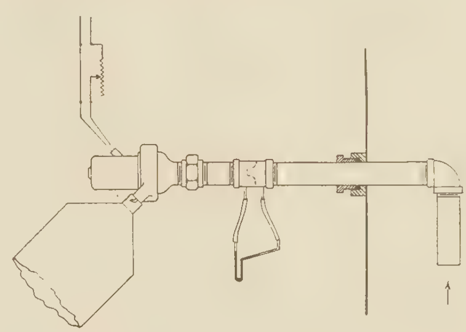


Fig. 1 A Simple Design of Dust Sampler With Filter Bag on Discharge Side of Blower

With virtually all types of flue-dust-sampling apparatus, the collection is accomplished by facing a tube into the stream and applying suction at the opposite end, with a dust-separating device located at some point in the sampling line.

A simple type of apparatus is shown in Fig. 1. The aerodynamics of dust particles dictates that that part of the moving stream drawn through the sampler must not change in velocity or direction at entrance to the sampler. Experimental results showing the errors caused by incorrect sampling velocities as determined by Fahrenbach (2), Zimmermann (3), and Caldwell (4), are reproduced in Fig. 2. Difference in size analysis of the dust being measured probably accounts for the disagreement between the three curves. Another error is introduced if the sampler does not face squarely into the gas stream. The measured values of this error (2, 3) have not been reproduced here, since it is a much less likely source of error, except where poor sampling

[1] Test Development Engineer, Brooklyn Edison Company, Inc. Mem. A.S.M.E. Mr. Hardie was graduated from the Alabama Polytechnic Institute with a B.S. degree in mechanical engineering in 1921 and later received his M.E. degree. He spent the following year at the Massachusetts Institute of Technology specializing in design and testing. He received early practical training with the Hardie-Tynes Mfg. Company, Birmingham, Ala., and was associated with the Westinghouse Electric & Mfg. Co. until 1926 as a steam-turbine designer. Since 1926 he has been engaged in power-station testing for the research bureau of the Brooklyn Edison Company, Inc.

[2] The term "flue dust" is applied to the solid refuse carried along with the gases of combustion and includes both cinders and fly ash.

Contributed by the Fuels Division and presented at the Annual Meeting of The American Society of Mechanical Engineers, held in New York, N. Y., Nov. 30 to Dec. 4, 1936.

Discussion of these papers should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until September 10, 1937, for publication at a later date. Discussion received after this date will be returned.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

[3] Numbers in parentheses refer to the Bibliography at end of paper.

locations are used. Samples should be taken in a long straight portion of the duct. A vertical run is preferable to a horizontal run as a sampling location.

Suction Apparatus

Several different devices have been used for producing the necessary suction for withdrawing the gas samples and overcoming the resistance of the separating device. Blowers of the vacuum-cleaner type are excellent when the resistance is not very high. They are used mostly with cyclone separators and with

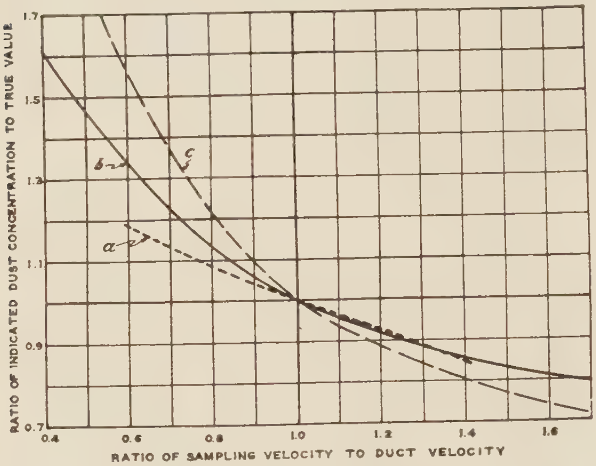


Fig. 2 Curves Illustrating the Magnitude of the Experimental Error Caused by Incorrect Sampling Velocity

(*a*, Plotted from data obtained by W. E. Caldwell and his associates with test equipment similar to that described in (4); *b*, Curves reproduced from Zimmermann (3) Fig. 14; *c*, Curves reproduced from Fahrenbach (2) Fig. 14.)

cloth bags located on the discharge side. For high resistance and large quantities, a steam siphon of the type used on condensers and pumps has been found to work well. Jacobus and Bailey (5) and Mackenzie (6) used a compressed-air ejector with a cloth-bag filter on the discharge side. The bag in this case had to be large enough to pass the compressed air as well as the sampled gas; otherwise, this method has much to commend its use. Water ejectors have also been used but mostly for small gas quantities and low resistance. Even laboratory types of reciprocating and rotary pumps have been used.

Determining Correct Sampling Rate

There are some investigators who prefer one of the automatic means of indicating when the correct sampling rate is being maintained while others prefer to measure the velocity in the duct and use the gas-metering device for indicating when this velocity is being maintained at the sampler inlet. In the latter case, traverses are made with a pitot tube and thermocouple, generally only just prior to each run, although check readings at intervals during the test can be made if found necessary. The disadvantage of this method is the inconvenience of converting velocity-pressure measurements into nozzle-differential readings. The gas pressure and temperature are generally lower at the nozzle and these differences must, therefore, be taken into account when determining what nozzle differential to hold.

Fig. 3 illustrates three different methods that have been used for automatically indicating the correct sampling rate. In Fig. 3*a*, two pitot tubes are used, one inside the sampler and one adjacent to the sampler tip. Equal velocity-pressure readings on the gages connected to the two pitot tubes indicate that the correct sampling rate is being maintained. This is probably the most accurate method for maintaining equal velocity. It has another advantage because the inside pitot tube serves as the gas-metering device. This method has two disadvantages: First, pitot tubes plug rapidly in a dust-laden gas stream; and, second, the sampler must be large to accommodate the pitot tube without too great a reduction in the gas-passage area.

The method shown in Fig. 3*b* utilizes two static-pressure tubes connected to a differential gage to indicate when equality of velocity has been attained. The outside tube is similar to a pitot tube but has no impact opening, and the other tube is connected to a piezometer ring located near the sampler tip. The static holes for this arrangement, as in the two-pitot-tube method, are likely to become clogged if they are made small enough to insure accurate readings. However, the size of the sampler tube has no limitation.

Fig. 3*c* shows how inverted-impact tubes are used to indicate the correct sampling rate. These tubes are less likely to clog, but the one facing into the mouth of the sampler may cause uneven flow of gas and dust into the sampler, unless it is exceedingly small in relation to the sampler size. The sensitivity of these inverted-impact tubes can be increased by flaring the ends.

Zimmermann (3) found automatic means for indicating correct sampling rates unnecessary, because the gas velocity in the ducts showed little change throughout a test. This has been the experience of other investigators (1, 4, 7). However, if the gas velocity fluctuates considerably in a test period, automatic means for indicating sampling rates would be desirable. Also, when an integrating gas meter is used for determining the quantity of gas sampled, automatic indication of adjustment has certain advantages.

Measuring Quantity of Gas Sampled

We come next to the means used for measuring the quantity of gas withdrawn as samples. Investigators are again divided,

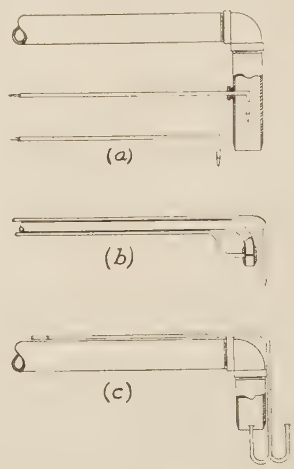


Fig. 3 Means Used to Indicate Automatically When Correct Sampling Velocity Is Being Maintained

(*a*, Equal velocity pressure on the two pitot tubes indicates correct sampling rate; *b*, Zero reading on differential gage connected to the two static tubes indicates correct sampling rate; *c*, Zero reading on differential gage connected to the two inverted impact tubes indicates correct sampling rate.)

this time between indicating and integrating types of instrument. Nozzles or orifice plates are the usual indicating type of metering device used. Stern (1) eliminated the nozzle by using the pressure drop through the cyclone separator, having previously obtained a calibration curve for pressure drop against flow.

A pitot tube located inside the sampler tube, as illustrated in Fig. 3*a*, is another indicating method. For the integrating method, the house type of gas meter has generally been used. Both indicating and integrating methods require gas pressure and temperature measurements to determine mass flow. The author, in a previous paper (7), described a method for maintaining a predetermined constant discharge pressure from all nozzles in a group, thereby reducing the number of readings and also simplifying regulation of flow and computation of results for multiple-sampler tests.

Mackenzie (6) described a simplified procedure in which no gas quantity measurements were made. With inverted impact tubes, similar to Fig. 3*c*, he maintained the correct sampling rate with the sampler located for an equal length of time at the center of several equal areas into which the duct was assumed to be divided. Then, from the quantity of dust collected, and knowing the sampler-mouth and duct cross-sectional areas, the total quantity of dust passing the section in a test run was computed by using the ratio of these areas.

The other test methods are based on determining the dust concentration[4] from which the total quantity of dust can be computed if the quantity of gas passing is known. In some cases, the total quantity of dust need not be determined because all that may be desired is the efficiency of the dust-separating

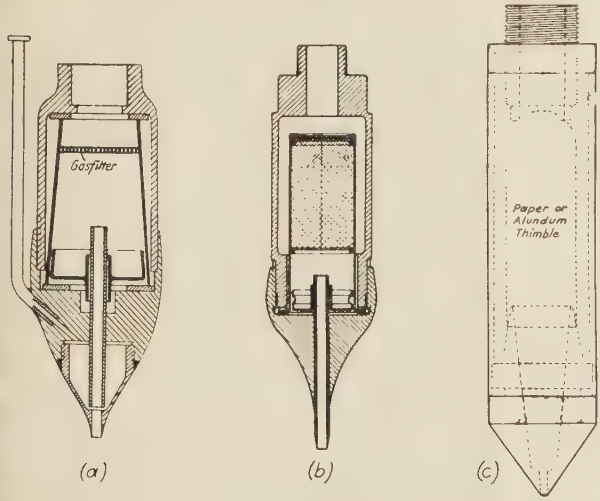


Fig. 4 Sampler Heads Containing Gas Filters

(The separation of the dust takes place inside the flue and the sampler, therefore, must be withdrawn to remove the dust; *a*, Design of head used by Zimmermann (3), which contains a Schott granular glass filter. The small tube on the side is the static-pressure connection for indicating the correct sampling velocity similar to that shown in Fig. 3*b*; *b*, Another design reported by Zimmermann (3), in which glass wool is used as the filtering medium; *c*, Design of head used by Research Corporation (11). Either a paper or alundum thimble can be used with this head.)

equipment. Since the quantity of gas is the same entering and leaving the separator, the efficiency can be computed from the dust concentration at the inlet and outlet without having to know the total quantities involved.

Dust-Separating Devices

A variety of devices have been used for separating the dust from the sampled gas. The separator is generally located outside of the gas duct, but some investigators have designed heads containing filters which are attached to the tips of the samplers. Fig. 4 shows three different types of head.

The paper-thimble and cloth-bag filters and cyclone separator are the three more generally used devices. Other less common devices are alundum, metal-screen, glass-wool, and Schott glass filters and the water-bubbling bottle. All of these methods have been made to perform reasonably well under certain operating conditions. No one means of separating the dust from the flue gas has been found entirely satisfactory for all operating conditions.

Paper-Thimble Filter. This device was perfected by Brady and Touzalin (8), and is generally spoken of as the Brady thimble. It has been used both inside and outside of the gas duct. When the gas temperature is high, paper thimbles will fail very easily. If the thimble is located outside of the duct, the sampled gas may be cooled sufficiently to eliminate this trouble. However, the gas can be cooled too much, thereby causing condensation on the thimble. A method of electrically heating the thimble casing to eliminate this trouble when the gas temperature is too low is used by a large steel company (9).

Due to the small gas-filtering capacity of these thimbles, they have been used almost entirely for pulverized-fuel installations, which do not require a large sampler because the dust particles are of small size. The diameter of sampler mouth used with these thimbles is generally $^1/_8$ or $^3/_{16}$ in., which is entirely too small to catch the large-size cinders produced in stoker-fired furnaces.

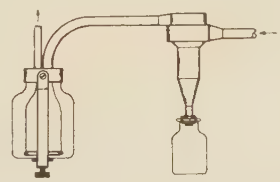


Fig. 5 Cyclone Separator and Cloth-Bag Filter in Series

(The main purpose of this combination is to reduce the tendency of the bag to give trouble when the cinder concentration is high. The cyclone can be made small because a high efficiency is not necessary. This design has been used by the Brooklyn Edison Co.)

Cloth-Bag Filter. Filters of this type are divided into two classes, those located ahead of the source of suction and those on the discharge side. Bags located ahead of the suction apparatus must be encased in an air-tight container, generally a glass jar, and are therefore limited in size. Bags located on the discharge side have no such limitation imposed on their size. However, they should not be made so large in proportion to the quantity of dust collected that an appreciable error is introduced when determining the weight of dust, either by emptying and weighing or by weighing the dust in the bag and then subtracting the tare weight of the bag.

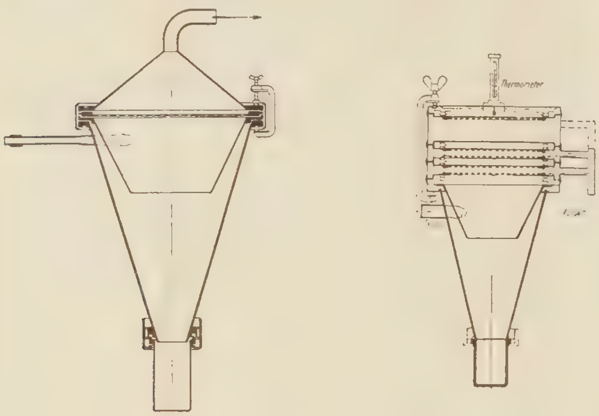
Both wool and cotton cloths have been used as material for the bags. The former is more expensive but will withstand a higher temperature. Even asbestos bags have been tried, but they are not considered very satisfactory. The cloth-bag filter can be made for large as well as small-size samplers; for a maximum sampler size of 1 in. with the bag on the inlet side of the suction device, and for almost any size with the bag on the discharge side. It is equally suitable for pulverized-fuel and stoker-fired installations. The chief disadvantage of cloth bags is their short life which often causes failures in operation, especially at high load.

Cyclone Separator. Constant resistance for a given gas flow, lack of limitation in size, and ease of removing dust sample are points that make the cyclone separator very desirable. The only drawback to its use is its efficiency of separation. Most investigators have considered a filter necessary on the discharge of the cyclone. Stern (1) developed a cyclone which, for a limited range of sampling rates, obtained nearly 100 per cent

[4] For the purpose of this paper "dust concentration" is defined as the weight of dust per unit weight of gas.

separation. For different duct velocities, the size of sampler mouth was changed to keep the rate of gas sampling within the required limits. As a check on the efficiency of the cyclone he recommends the use of an electric precipitator in the discharge line. Figs. 5 and 6 show methods used by other investigators for combining a cyclone and filter. These combinations retain most of the advantages of the cyclone without having to change the sampler tips to assure complete separation.

Alundum Filter. If the gas temperature is above 350 F or if the gas is quite moist, alundum filters have been used to replace



(a) (b)

Fig. 6 Cyclone Separator With Internal Filter for Securing Complete Removal of Dust

(*a* The filter consists of a sheet of filter paper backed up with a metal screen, both of which are clamped between the cover and the body of the separator. See paper (3) by Zimmermann; *b*, A similar design used by Rosin and Rammler (12) which has several sheets of filter paper in parallel to reduce the resistance to gas flow.)

paper thimbles. In some cases the alundum filter is made the same size and shape as the paper thimbles so that the two are interchangeable (see Fig. 4*c*). The high resistance of alundum filters is a serious handicap to their use.

Metal-Screen Filter. As a substitute for cloth bags when the temperature is above 300 F, monel-metal screens of 100 mesh have been used (7). For tests on stoker-fired installations, the openings in the screen are quickly covered, thereby preventing further loss of small-size particles. The tests must be of such duration that the initial loss of small particles will be negligible. Like the alundum filter, the resistance of metal-screen filters is high, especially after the test run has been in progress for some time. If the rate of collection is high, the test run must be interrupted several times to brush the dust from the screens.

Glass-Wool and Schott Glass Filters. These two types of filter have been used mostly for laboratory experiments, although Zimmermann (3) reports their use on field tests. If the dust sample is desired for size analysis or combustible content, the separation of the dust from the glass wool presents a problem. The high resistance of the Schott glass filter is the main objection to its use.

Water-Bubbling Bottle. Separation of dust from the gas by bubbling the gas through water is a method that has been resorted to when the gas contained too much moisture to permit the use of any of the filter methods. It has the serious disadvantage that a large quantity of water must be separated from the dust by filtration and then evaporation.

General Considerations

Classifying dust samplers according to the means used to separate the dust has caused undue emphasis to be placed upon this function of the sampler, when emphasizing the sampling procedure is much more important. Efficient separation can be obtained with all of the separating devices. The choice between them should be governed largely by the kind of test to be made and the operating conditions to be encountered.

The most likely source of error in flue-dust measuring is due to faulty spotting of the samplers in the cross section of the gas passage. At best, a sampler can be expected to indicate the dust concentration only at the points where it is spotted. With a variation in dust concentration as great as 10 to 1, which is not uncommon even in long straight ducts, the spotting of the samplers is a potential source of error. Samples must be taken from at least 12 points to obtain reasonably reliable results. The samples can be obtained either by traversing with one or more samplers or by operating separate samplers at each point.

All samplers require considerable attention both in preparation for test and throughout the test period. Simon (10), however, reports the development of a recording dust-concentration meter, but whether this instrument would be satisfactory for test purposes is questionable.

To the author's knowledge, only one flue-dust sampler is on the market, a vacuum-cleaner type manufactered by Hudson H. Bubar.[5] Other types described therein were built specially.

BIBLIOGRAPHY

1 "The Measurement and Properties of Cinders and Fly-Ash," by A. C. Stern, *Combustion*, vol. 4, June-July, 1933, pp. 35–47.

2 "Die Dynamik des Staubes und ihr Einfluss auf die Staubgehaltmessungen," by W. Fahrenbach, *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 2, 1931, pp. 395–407.

3 "Messung von Flugstaub in Rauchgasen," by E. Zimmermann, *Zeitschrift des Vereines Deutscher Ingenieure*, vol. 75, 1931, pp. 481–486.

4 "Characteristics of Large Hell Gate Direct-Fired Boiler Units," by W. E. Caldwell, Trans. A.S.M.E., vol. 56, 1934, paper FSP-56-2, pp. 73–75.

5 "Removal of Ash and Loss of Carbon From Boiler Furnaces," by D. S. Jacobus and E. G. Bailey, Proceedings of the Second International Conference on Bituminous Coal, 1928, vol. 2, pp. 241–275.

6 "Recovery of Fly Ash From Pulverized-Fuel Stacks by Use of Stack Sprays," by J. W. Mackenzie, Trans. A.S.M.E., vol. 53, 1931, paper FSP-53-5, p. 53.

7 "Cinder and Fly-Ash Measurements," by P. H. Hardie, *Combustion*, vol. 6, March, 1935, pp. 10–16, and (discussion) April, 1935, pp. 37–38, and May, 1935, p. 35.

8 "The Determination of Dust in Blast-Furnace Gas," by W. Brady and L. A. Touzalin, *Journal of Industrial and Engineering Chemistry*, vol. 3, 1911, p. 662.

9 "Methods of the Chemists of the United States Steel Corporation for the Sampling and Analysis of Gases," 3rd edition, 1927, p. 130.

10 "A Recording Dust Concentration Meter for Blast Furnace Gas," by A. W. Simon, *Blast Furnace and Steel Plant*, vol. 18, 1930, pp. 1686–1689 and 1700.

11 Technical Bulletin No. 3E, Research Corporation, 1931.

12 "Die Proxis der Flugstaubmessung," by P. Rosin and E. Rammler, *Braunkohle*, vol. 34, 1935, pp. 505–512, 525–530, and 542–546.

Pease Anthony Gas Scrubbers

By M. D. ENGLE,[1] BOSTON, MASS.

IN THE Kneeland Street boiler plant of The Edison Electric Illuminating Company of Boston, two 250,000 lb per hr and one 350,000 lb per hr pulverized-coal-fired boilers are in-

---

[5] 15 Park Row, New York City.

[1] Superintendent, station engineering department, The Edison Electric Illuminating Company of Boston. Mem. A.S.M.E. Mr. Engle received the degree of B.S. in engineering from the University of Michigan in 1918 and, until 1922, was associated with the Consolidated Gas, Electric Light & Power Co., Baltimore, Md., first as an assistant construction inspector on an addition to its Westport central station and then as assistant to the electrical engineer. From

stalled for supplying steam to the district heating system in downtown Boston. Each boiler is equipped with two Pease Anthony gas scrubbers, manufactured by the B. F. Sturtevant Company, for removing the solid matter from the flue gases before they are discharged to the atmosphere.

Details of Construction

As can be seen from Fig. 1, these scrubbers consist of a vertical, cylindrical shell with a tangential gas inlet at the bottom and a central gas outlet, with antispin vanes, at the top. In the center of the scrubber, a vertical spray manifold is located which supplies the scrubbing water through approximately 90 $^3/_{16}$-in. nonclogging nozzles.

The steel shells are lined with plastic stack lining and acidproof brick set in acidproof mortar. The central spray-nozzle manifolds are made of Haveg, and the nozzles are made of hardened volcanic lava. Each nozzle handles about 1.75 gpm at 35 lb pressure. The scrubber drain lines are of rubber-lined steel pipe with a stoneware lining at the outlet from the scrubber to resist the erosive action of the water and solid matter leaving

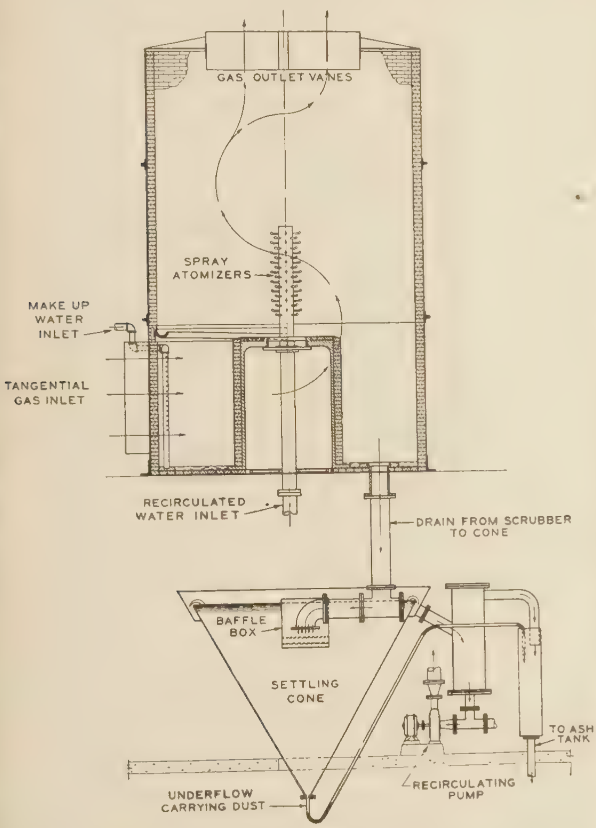


Fig. 1 Section Through Pease Anthony Gas Scrubber Showing Details of Construction and Arrangement

the scrubber. They discharge into a Callow cone for removing the greater part of the solids before the water is recirculated to the scrubber spray nozzles.

The steel Callow cones have 60 deg angles and are protected against corrosion by a rubber latex paint known as Sealvulc. The water enters at the center through a baffle box and flows outward and over the edge into a collecting trough and then passes to the recirculating pump. The solids with about 10 per cent of the water, are removed at the bottom and drain through rubber-lined steel or stoneware pipe to settling tanks.

The recirculating pump is rubber-lined and has a rubber-covered impeller. One pump recirculates the water to the two scrubbers serving one boiler.

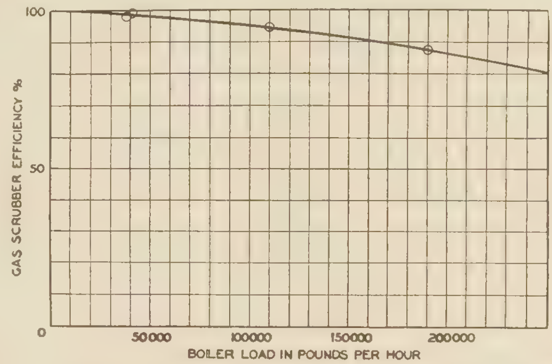


Fig. 2 Efficiency Curve Obtained From a Test of Two Scrubbers Serving a 250,000 Lb per Hr Boiler

The duct work, fans, and flues to the chimneys are sandblasted and painted with three coats of General Electric bakelite varnish No. 428, which is baked according to a schedule to give the greatest toughness and corrosion resistance.

Sufficient hot air, from the air-heater outlet, is discharged into the induced-draft fan inlets to reduce the relative humidity of the gas to approximately 50 per cent.

Operation Methods

In operation, the gas enters near the bottom and is given a violent spin by the tangential inlet. Scrubbing water enters through the many nozzles in the central manifold and is broken up into a very fine spray. The gas is saturated by the spray water, the solid particles are wetted and their weight increased, and both the solid matter and excess water are separated from the gas by the centrifugal force of the gas spin.

The gas flows upward and out through the central opening at the top, while the scrubbing water flows through the gas stream to the side walls of the scrubber. The water and solid matter drain down the side walls to the bottom of the scrubber and keep the side walls and bottom continuously wet and flushed off. The spinning gas scrubs the wet side walls continuously and aids materially in the scrubbing of the gas.

The gas-pressure loss through the scrubbers is approximately $1^1/_2$ in. of water at full load.

These are, so far as known, the only flue-gas scrubbers in this country using recirculated scrubbing water. At this plant, tidewater is not available, and recirculation is an economic necessity. The waste water in the boiler plant, such as boiler blowdown and backwash and rinse water from the zeolite softeners, is used as make-up water for the scrubbers.

The recirculating pumps handle from 1.5 to 2.0 gpm per 1000 cfm of gas scrubbed at full load. Since the quantity of scrubbing water is maintained constant, the water-to-gas ratio is much higher at light loads, which probably accounts for the higher efficiency of collection obtained at less than full load.

The temperature of the recirculated scrubbing water varies from approximately 110 to 140 F, with temperatures for the gas entering the scrubber varying from 350 to 500 F. The acidity

1922 to 1925, he was assistant to the chief mechanical engineer with McClellan & Junkersfield, Inc., severing that connection to become assistant to superintendent of the station engineering department with The Edison Electric Illuminating Company of Boston. In 1935, he assumed the duties of his present position.

of the scrubbing water, with 0.50 to 0.75 per cent of sulphur in the coal, varies from 0.05 to 0.30 per cent of acid calculated as sulphuric acid. While most of the acid in the water is sulphuric, traces of hydrochloric, nitric, and sulphurous acids have been found. The pH of the scrubbing water varies from 3.00 to 1.75.

This water is very corrosive, and very few metals or alloys that will withstand its corrosive action are available. As will be noticed, nonmetallic materials are used exclusively in the construction of these scrubbers wherever a possibility of scrubbing water being present exists. Four of these scrubbers have been in operation 6 years and two of them for 5 years. We feel that the major design and operation problems have been solved, and that the scrubbers are now developed to a point where they can be installed with the confidence that they will operate satisfactorily for the purpose intended.

A careful test has been conducted on the pair of scrubbers serving one of the 250,000 lb per hr boilers. Although any test on dust-catching apparatus is open to question, we believe that the results of this test are reliable. Fig. 2 shows the efficiency curve obtained from this test. During the last two runs, the dust content of the entering gas was very low, 0.600 to 0.276 g per cu ft. Had the content been higher, the efficiency of collection would also have been better.

Scrubbers in Good Condition After 6 Years Service

The steel shells and their acidproof-brick linings have been free from trouble and, after 6 years of operation, appear to be in as good condition as the day that they were installed. Cast-iron spray-nozzle manifolds, 1 in. thick, were used at first and had a life of about one year. Now, manifolds of Haveg are being used, and some of these have been in service two years. This material appears to have a long life if the scrubbers are not operated without water but does have a somewhat lower temperature resistance than would be desirable. Nozzles of an acid-resisting alloy were used at first and failed within less than 6 months. Molded bakelite nozzles were tried and failed within 10 days. Nozzles of hardened volcanic lava have been in service 2 years and appear to have a life of three or more years.

To guard against high temperatures in the scrubbers, a set of emergency spray-nozzles has been installed in the scrubber inlet and is supplied with water from the scrubber make-up pumps. An automatic valve admits water to these nozzles whenever the pressure delivered by the recirculating pump falls below a safe value.

Where rubber-lined pipe is used, a hard-rubber lining has been found to resist the corrosive action of the scrubbing water best. Soft-rubber linings best resist the erosive action of the solids carried in suspension in the scrubbing water. Some semi-hard-rubber-lined drain lines have been in continuous service for 6 years without failure, while some soft rubber-lined pipes subjected to turbulent flow have failed completely in 3 years. When properly installed, chemical-stoneware drain lines seem to be well suited for handling the scrubber water and entrained solids. We have not had a long enough experience to secure data on the life of this material but intend to use it in the future.

The Sealvulc latex paint stands up on the Callow cones satisfactorily for 1 year. The surface is then cleaned and patched, and two additional coats applied with a paint spray gun. This treatment is relatively inexpensive and is satisfactory.

The rubber-lined pumps with rubber-covered impellers were manufactured by the Allis Chalmers Mfg. Company, and the rubber work was done by the Manhattan Rubber Company. They operate at a head of approximately 50 lb and have performed very satisfactorily as recirculating pumps.

By sandblasting and repainting the ducts on the discharge of the scrubbers and the inside and rotor of the induced-draft fans annually, they apparently will last for many years. After 6 years of operation, the fans are almost as good as new, but, if the fans and rotors are not repainted annually, serious corrosion takes place.

Dehydration of Solid Matter

Another problem, which has been difficult to solve, has been the dehydration of the solid matter after it has been caught by the scrubber. The solids scrubbed from the boiler-flue gases are so small in size that they settle very slowly and do not, by settlement, form a compact mass which can be handled by ordinary means. The permeability of the solids is so low that removing sufficient water from the voids to give a semidry cake which can be easily handled is very difficult. We have a device for this purpose in service which seems to offer a satisfactory answer to the problem.

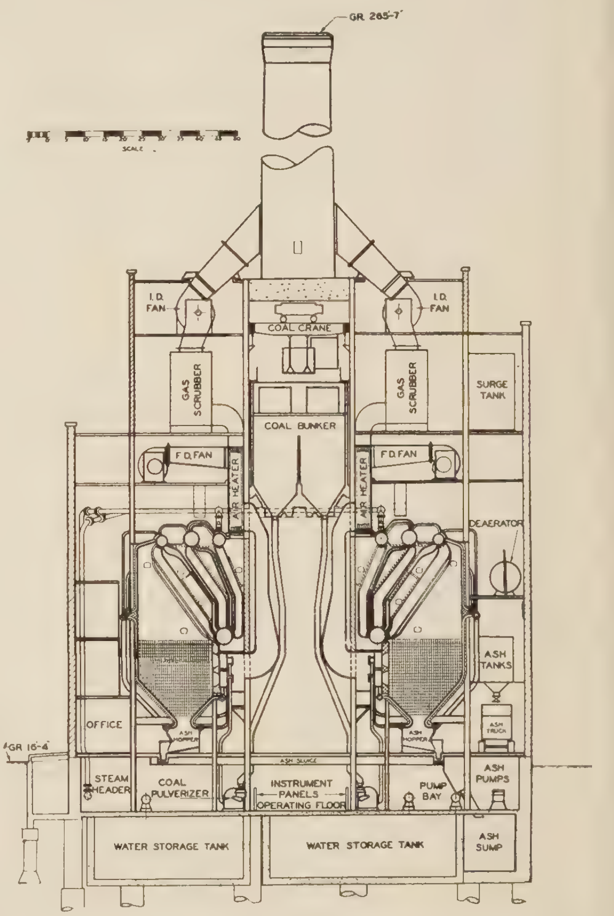


Fig. 3 Cross-Section of the Kneeland Street Station Showing Location of the Gas Scrubbers With Relation to Rest of the Equipment

Fig. 3 shows how these scrubbers have been fitted into the Kneeland Street Station. As will be seen, they are located between the air-heater outlet and the induced-draft inlet.

Many problems remain to be solved before the perfect gas scrubber is developed. In spite of the lack of fundamental research, however, many satisfactory gas-scrubber installations have been made and are in everyday operation. Many of us believe that the gas scrubber is the most satisfactory apparatus available for removing solid matter from boiler-flue gases.

Hell Gate Spray Zone Gas Washer

By J. J. Grob,[1] New York, N. Y.

FLY ASH is difficult to remove from flue gases because of the large percentage of extreme fines. A substantial percentage of coarse grit may also be present at times. Many types of dust eliminator which proved to be fairly successful in dealing with stoker cinder have failed to provide satisfactory elimination of fly ash in connection with pulverized-coal boilers. Several types of spray eliminator for powdered-coal boilers have demonstrated that exceedingly high dust-eliminating efficiency is made possible by washing the gases with finely divided water sprays and further indicated that the performance is not selective as to the size of dust particles. In the present spray-eliminator design, an important saving in water requirements has been made possible by combining the effects of inertia, downward flow, change of direction, and change of velocity together with the agglomerating action of the water sprays.

The Hell Gate spray zone fly-ash eliminator is a comparatively simple and compact arrangement for the application of sprays in the removal of fly ash from flue gases. It consists essentially of a reversing chamber with a spray header carrying a row of spray nozzles near the point of gas reversal, as shown in Fig. 1.

The entrance chamber is positioned so that the gas flow is directed downward and the velocity is increased as the gas approaches the spray zone. After it passes through the spray zone, the outlet passage is enlarged so that the gas can leave the spray zone at a reduced velocity as it turns abruptly upward. In its upward path, the gas is directed through corrugated or alternately spaced dehydrating plates to arrest entrained moisture and uncaught dust agglomerates. This arrangement is illustrated in Fig. 2. Jetting nozzles are provided to remove periodically accumulations of lodged fly ash from the dehydrating plates, generally about two to three times per day.

Three of these eliminators are now in service at the Hell Gate Station serving boilers Nos. 81, 82, and 83, each having a capacity of 400,000 lb of steam per hour. Due to crowded conditions in the eighth-boiler row, no other type of fly-ash eliminator, which might have been considered, could be accommodated in the limited space available. One hundred and fifty gallons of sea water per minute is utilized in the spray zone of each eliminator. Sea water is employed in the spray zone as this is the cheapest source of water supply, involving relatively small pumping charges.

Many exhaustive tests were conducted on No. 83 eliminator which was the first installed. Fig. 3 and Table 1 indicate a general dust-elimination efficiency of 97 per cent and some details of test results. Methods of test followed experience gained with tests of various experimental catchers at Sherman Creek Station over a period of years. Multiple dust-sampling traverses were conducted at velocities corresponding to the gas velocity at the

[1] Engineer of Tests, New York Edison Company, Inc. Mem. A.S.M.E. Mr. Grob was associated with the Electrical Testing Laboratories, New York, N. Y., from 1911 to 1914, when he accepted a position at the main power station of the Hudson & Manhattan Railroad, Jersey City, N. J., where he remained until 1920. During this period, he was a student at Pratt Institute, Brooklyn, N. Y., in the electrical course, being graduated in 1917, and continued his studies at Columbia University by taking special courses and later at Polytechnic Institute of Brooklyn, receiving the degree of M.E. in 1926. After leaving the Hudson & Manhattan, he was employed by the Dwight P. Robinson Co., as designer and checker on the mechanical and electrical features of the Colfax power station for the Duquesne Light Company, Pittsburgh, Pa., for a year. In 1921, he was appointed to his present position with the New York Edison Company, Inc.

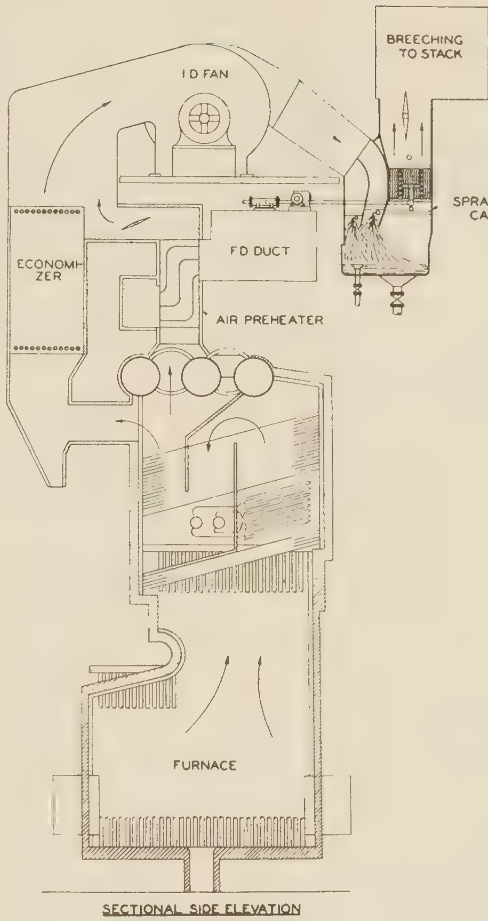


Fig. 1 Sectional Side Elevation of Hell Gate Spray Zone Fly-Ash Eliminator

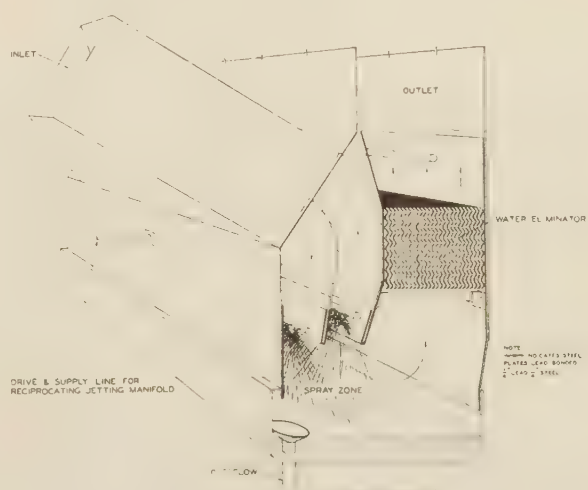


Fig. 2 Sectional Perspective Showing Details of Construction

TABLE 1 CINDER-CATCHER TEST OF BOILER NO. 83

	Inlet								Outlet					
Peripheral location	1E	2E	3E	4E	1W	2W	3W	4W	1	2	3	4	5	6
Orifice no.	9	10	11	12	13	14	15	16	1	2	3	4	5	6
Separate Tests of the Individual Orifices (A)														
	0.67	1.28	0.89	1.44	0.32	1.19	0.31	0.37	2.55	4.12	2.89	2.45	3.70	3.05
	10.05	19.20	13.36	21.60	4.80	17.86	4.65	5.55	76.5	123.6	86.7	73.5	111.0	91.5
	12.17	23.22	16.17	26.17	5.80	21.60	5.62	6.71	92.5	149.4	105.0	88.9	134.2	110.8
	1.36	1.34	1.46	1.48	0.72	1.52	1.62	1.66	5.13	5.41	3.97	2.43	3.56	4.98
Flue gas metered, cfm[a]	20.40	20.10	21.92	22.20	10.80	22.80	24.32	24.92	153.9	162.3	119.1	72.9	106.8	149.4
Total flow, cu ft	24.66	24.32	26.52	26.82	13.08	27.58	29.41	30.16	186.1	196.3	144.1	88.1	129.2	180.8
Total gas sampled, cu ft[b]	1.44	1.50	1.46	1.47	1.17	1.57	1.58	1.63	....	....	....	....	....	....
	21.60	22.52	21.92	22.04	17.57	23.58	23.72	24.43	....	....	....	....	....	....
	26.16	27.22	26.50	26.68	21.23	28.51	28.68	29.60					....	....
	0.35	0.71	1.05	1.38	1.21	1.66	1.55	1.56					....	....
	5.25	10.66	15.75	20.69	18.16	24.92	23.22	23.40					....	....
	6.35	12.89	19.07	25.02	21.98	30.16	28.12	28.32			....		....	....
Total Results for the Individual Orifices (B)														
Total gas sampled, cu ft[b]	69.34	87.65	88.26	104.7	62.09	107.9	91.83	94.79	278.6	345.7	249.1	177.0	263.4	291.6
Dust, g	6.6	9.6	10.9	21.0	5.2	14.0	16.4	17.9	1.35	0.75	1.85	0.95	1.65	0.85
Density per 1000 cu ft sampled, grains	1470	1690	1905	3100	1290	2005	2750	2920	74.7	33.4	114.6	82.7	96.8	44.9
Cinders per 1000 lb of gas, lb	2.69	3.09	3.48	5.67	2.36	3.67	5.04	5.34	0.137	0.061	0.210	0.152	0.177	0.082

Totals for Inlet and Outlet (C)

	Inlet	Outlet
Total gas sampled, cu ft[b]	706.5	1605.4
Dust, g	101.6	7.40
Density per 1000 cu ft sampled, grains	2220	71
Cinders per 1000 lb of gas, lb	4.06	0.130

[a] Corrected for a temperature of 68 F and a pressure of 30 in. of mercury.
[b] At a temperature of 68 F and a pressure of 30 in. of mercury. Composition of gas: CO_2, 10 per cent; O_2, 9.5 per cent; N_2, 80.5 per cent.

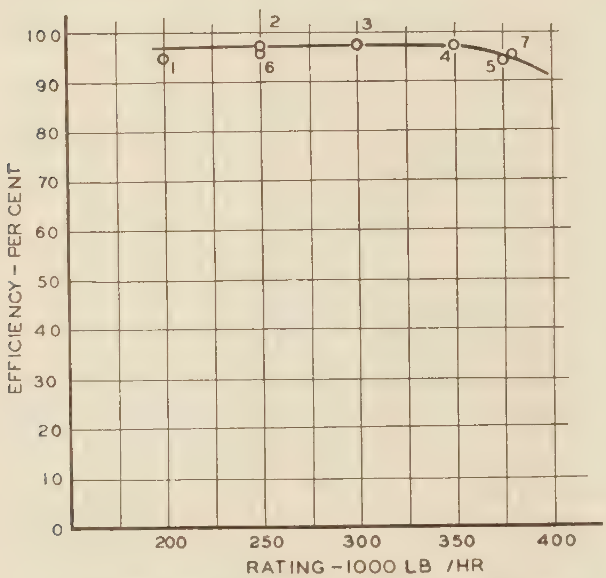


FIG. 3 EFFICIENCY CURVE OF CINDER-CATCHER TESTS

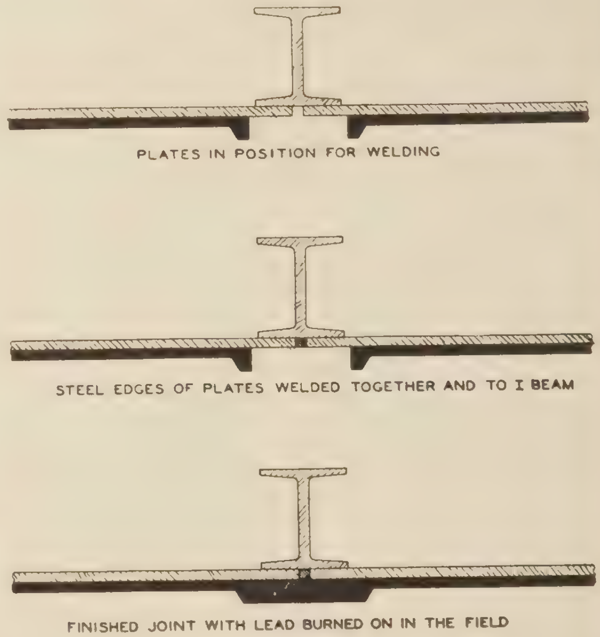


FIG. 4 METHOD OF PROTECTING WELDED SEAMS IN HOMOGENEOUS LEAD-COVERED PLATES

position of sampling. The gas samples were drawn through filter bags and then through metering orifices.

Many kinds of material were exposed to the gas and salt water to determine their suitability for corrosion resistance. In the recent installations on boilers Nos. 81 and 82 lead-lined steel plates are used for the walls exposed to water. The lead is $^1/_4$ in. thick and is bonded to the steel by the homogeneous process. Fig. 4 indicates how the welded joints are built up with lead and Fig. 5 shows a sample of lead-clad plate. While planning for corrosion and erosion resistance was necessary, this problem has been reduced to the minimum for wet catchers because of the small quantity of spray water, use of dehydrating plates, and avoidance of gas supersaturation.

The bottom pan of No. 83 eliminator consists of $^3/_4$-in. steel plates, bare except for occasional coats of emulsified asphalt. This unit has been in service over 5 years, and the only attention that the pan has required has been the welding over of rivet heads which had been worn down by the abrasive action of grit in motion. If future experience indicates any need of further protection, the pan could be lined with brick or cement. The most severe corrosion service is experienced on the walls of the container just under the dehydrating plates where acid concentrations may build up. This situation has been met by using homogeneously bonded lead-clad plates. Since the operating availability of the eliminator greatly exceeds the operating availability of the boiler, no by-passes have been considered necessary on the eliminators installed at Hell Gate.

Operating attention is simple, involving the backwashing of twin strainers on the water supply and jetting the dehydrating plates about once every 8 hours. Inspection of the nozzles takes place on a Sunday outage. Fouling of nozzles is infrequent. In the course of a year and a half or two, when the dehydrating plates begin to wear thin, any convenient boiler outage involving two or three days is utilized to replace the plates. As the transite

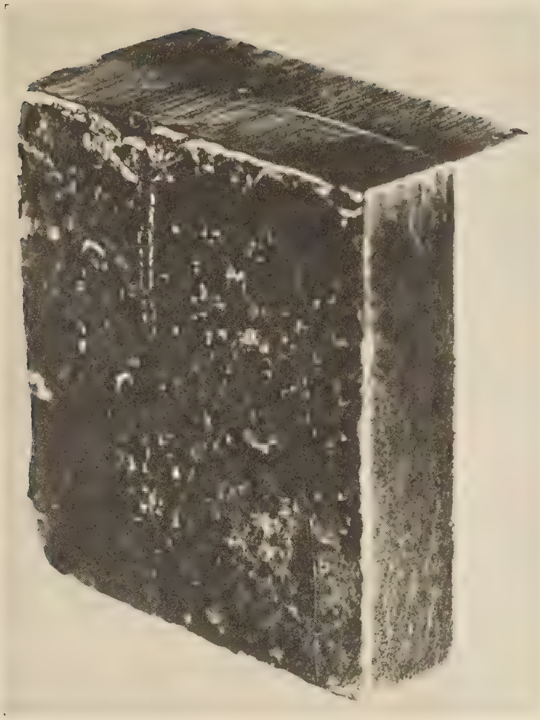


FIG. 5 SAMPLE OF 1/4-IN. LEAD PLATE BONDED TO A STEEL PLATE OF EQUAL THICKNESS

dehydrating plates are comparatively cheap, considerable latitude in the selection of time for replacement is provided.

Cindervane Fan

BY H. F. HAGEN,[1] BOSTON, MASS.

THE CINDERVANE was, so far as I know, the first successful device to utilize changes in direction of flow that occur in a fan impeller to separate dust from flue gases. The possibilities of such action were emphasized in 1916 by W. S. Finlay who wrote a complete and seemingly serious specification calling for cinder-eliminating fans for induced draft at the 59th Street Station of the Interboro Rapid Transit Company. In an interview with a rather bewildered fan engineer who had never heard of any such apparatus, Mr. Finlay explained that, while he knew nothing of the kind was on the market, he thought there should be and he wanted us all to consider the problem.

About a year later, our research department invited Mr. Finlay to witness a test on a model 24-in. fan. The results of the test were satisfactory and two 12-ft fans were ordered. The impeller design was based on the steel-plate paddle wheel and provided outwardly inclined channel irons attached to the blades to convey the cinders to collecting chambers in the sides of the casing.

The fans were installed and put in operation in 1918 and gave a satisfactory performance. They handled the required duty at a fair efficiency and more than met the guaranteed cinder-recovery efficiency. Each fan actually threw down 250 lb of cinders per hour, when the boilers were operating at high load, which in those days, was 250 per cent of the rating.

Mr. Finlay offered us an order for 14 more units to equip the station completely but required a delivery that we could not meet in view of the business already in our shop. I have always felt that, if we could have filled that order, the history of the Cindervane would have been different. That installation would, in all probability, have resulted in a large business and encouraged research and commercial activity. As it was, the device achieved some notable successes and a slowly increasing business, about a quarter of a million dollars in the next 5 years. The advent of pulverized coal and the large increase in induced-draft pressures made that specific design obsolete.

The Cindervane was a successful apparatus and may serve to illustrate the advantages and disadvantages of this type of cinder eliminator. The former are

(1) Draft loss for the cinder elimination is small. The required modification of the fan blades reduces the fan efficiency less than 5 per cent.
(2) Only a small amount of additional space is required.

The disadvantages are more numerous; they are

(1) The blade becomes a limiting factor from a standpoint of strength
(2) Abrasion is rapid
(3) Dust-separating efficiency is low with micronic sizes.
(4) Passages for the separated dust are necessarily small and some trouble from clogging may be expected.

However, the writer's laboratory experience has shown that (3) applies to all attempts at dry centrifugal separation in limited space, so that this objection is generic rather than specific and typical.

In view of modern trends in power-plant design, further development of the dust-separating fan impeller do not appear commercially attractive.

[1] Manager of research, B. F. Sturtevant Company. After being graduated from Stevens Institute of Technology in 1907 with the degree of M.E., Mr. Hagen worked for approximately 18 months as piece checker in the Erie Railroad shops at Cleveland, Ohio. For about the same length of time, he was an electrical and construction engineer with Walter Kidde, New York, N. Y., and in 1910, accepted the position of engineer of design and tests with the Green Fuel Economizer Company, Beacon, N. Y. He severed this connection to accept his present position in 1916.

Cleaning Combustion Gases by Electrical Precipitation

BY C. W. HEDBERG,[1] BOUND BROOK, N. J.

COTTRELL electrical precipitation processes are an established means of fly-ash and cinder elimination. Their principal application, in this field, is in those cases where removal of from 90 to 98 per cent of the total suspended material carried by the gases is necessary or desirable. At the end of 1935, 19 installations were handling gases from 61 boilers with a normal steam output of 19,700,000 lb per hr in the last year, users have purchased 12 installations for 25 boilers with a combined steam output of 6,800,000 lb per hr.

THREE PRECIPITATOR TYPES AVAILABLE

The composition-plate precipitator continues to be preferred, six of the twelve installations purchased in 1936 being of this

[1] Chief of technical and development department, Research Corporation. Mr. Hedberg's connection with electrical precipitation dates back to 1916 when he first joined the Research Corporation, and this connection has continued except for a three-year period spent in the research department of the New Jersey Zinc Company. He is a graduate of Worcester Polytechnic Institute, a member of the American Institute of Chemical Engineers, and author of several papers on the application of electrical precipitation.

type. Because of weight and available-space considerations, two additional types, have been added, one embodying a rod-curtain collecting electrode and the other a vertical-flow pocket electrode. Five of the former and one of the latter have been built in 1936.

Construction and operation of the composition-plate precipitator is generally known and requires no extensive description. It is built in two or more separate banks of electrodes in series, each section consisting of as many as 15 parallel ducts formed by large concrete slabs that act as grounded collecting electrodes. Discharge electrodes hang centrally in the ducts and, when energized, charge the particles suspended in the gases and remove them from the gas stream to the collecting electrodes. When the deposit has reached a certain depth, a large portion loosens from the collecting electrode and drops into the hopper as heavy agglomerate, and the remainder is removed by a scraping system at regular intervals.

In general arrangement, the rod-curtain precipitator is markedly similar to the concrete-plate unit, the principal difference being in the type of collecting electrode and the method of dust removal. Instead of large concrete plates, the collecting electrodes are curtains consisting of a pipe framework in which are threaded a number of vertical parallel rods. These curtains are hung from the top so that they can be moved in their plane and forcibly returned against an anvil at the bottom, thereby vibrating the curtain throughout and dislodging the accumulated dust which falls into the hoppers. The rapping is carried out continuously or at necessary intervals through a mechanism actuated by solenoids, the whole operation being automatically controlled. For equal gas volumes, the height and width of the rod-curtain precipitator are essentially the same as dimensions for the concrete-plate type. The former is $3^1/_2$ ft shorter and weighs approximately 45 per cent less than the latter.

The vertical-flow pocket-electrode precipitator is particularly adapted to removal of cinders and soot from the combustion gases of stoker-fired boilers, and this has been its principal application. On fly ash from pulverized coal, it is just as effective as the two other types but is somewhat more expensive, and this fact limits its use to those cases where it can be furnished in economic-size units and fitted into existing arrangements to effect substantial savings in costs of supports and flue connections.

This precipitator differs from the other two in that the gases to be cleaned enter through the hopper, rise vertically through the ducts and leave through a breeching connected into an existing stack or through a stub stack which is carried on the precipitator itself.

The ducts are formed by parallel electrodes built up of six individual sections or hung from a top member. Pockets are formed in the sides of these boxes which provide louver-like openings into the interior, and, when the electrodes are vibrated by a mechanism provided for this purpose, the dust deposited on the electrode surface is loosened and falls through the openings into the box and is carried down into the hopper in a quiescent zone where the possibility of its becoming resuspended in the moving gases is little, if any. The arrangement of discharge electrodes and supports is, in general, identical with that in the other types described.

While the height is greater, it occupies less floor space than the other two types. In weight, it compares favorably with the rod-curtain precipitator.

Methods of Energizing

The usual method of energizing precipitators by rectified, full-wave current at a high potential is well known, and, when so energized, the power consumption is approximately 3 kwhr per 1,000,000 cu ft of gas cleaned. In the last year, mechanical rectifiers have been designed for a circuit employing half wave instead of full wave, and this promises to be a very definite advance in the art.

One half-wave mechanical set will do the work of two full-wave electrical sets with approximately half the power consumption and no measurable loss in efficiency. Electrical operation is smoother with less arcing in the precipitator, which has substantially decreased the scraper-chain and discharge-electrode breakage that has occurred on some installations as a result of excessive arcing.

General Arrangement of Precipitators

Most of the early precipitators for this service were located on the power-house roof between the induced-draft fan and the stack. In later years, and particularly on present new construction, most of them are located after the preheaters and before the induced-draft fans, and, while some continue to be located on the roof, a number are wholly within the buildings.

Not only does the location ahead of the fans markedly decrease fan-blade errosion, but it also simplifies the problem of distributing the gases over the cross-section of the precipitator. These desirable results are due to the fact that the gases leaving a preheater are usually moving through a much wider flue and at lower velocities than at the exit of the fan.

Operating Results

Builder's tests, employing the Brady method to determine average concentration of suspended matter in the gases throughout the cross-section of the inlet and outlet flues, have been conducted on most of the concrete-plate installations to secure performance data. These have shown removals consistently in excess of 90 per cent at normal ratings and, as these ratings are exceeded, the efficiency shows a drop of about 5 per cent at 125 per cent of rating and 12 per cent at 150 per cent. Generally, the percentage efficiency is slightly less on material coarser than 200 mesh than on finer, but, since the former usually comprises less than 10 per cent and in some cases as little as 5 per cent of the total suspended material, this characteristic is of minor importance.

As rod-curtain precipitators have been built only within the last year, operating results are now available on only one precipitator of this type. This showed an average efficiency of 94 per cent at rated volume and 90.3 per cent during flue-blowing periods.

With the pocket-electrode type of precipitator, efficiencies in excess of 90 per cent have been obtained in removing cinder, ash, and soot from combustion gases from stoker-fired boilers. The result has been practically invisible stack exits.

Static-pressure drop through a precipitator amounts to approximately 0.2 in. of water at normal ratings. Hence, no appreciable interference with draft conditions occurs.

Maintenance costs on the units have been very low. A recent survey made by a disinterested party indicates that they will not exceed 1 cent per ton of coal fired.

Increasing attention is being given to the inclusion of means for eliminating the discharge of cinders and fly ash from boiler stacks, particularly where new construction is involved. Furthermore, guarantees of 95 per cent and higher have already been specified on two installations so that the trend may be toward even cleaner exits. To the present time, electrical precipitators have played an important part in solving the problem, and continuous efforts are being put forth to increase their utility in this field.

Thermix Recirculator and Controlled Multicyclone

By L. C. WHITON, JR.,[1] PORT CHESTER, N. Y.

ORDINARILY the apparatus under discussion is considered as dust collectors. They might be more appropriately called dust losers because we are not interested in the material collected. As a matter of fact, many letters have been received from plants using our dust collectors, telling what a nuisance it is to collect so much dust. We are interested in the quantity and kind of dust that is lost.

At present, if between 8 and 10 per cent of the fly ash in a pulverized-fuel installation is allowed to escape, that is generally considered to be satisfactory operation. Our attention should, therefore, be concentrated upon what type of dust escapes, as well as how much is collected. The quality from a nuisance standpoint is fully as important as the quantity.

Fine Dust Constitutes the Minimum Nuisance

We recently made a test on fly ash containing 22 per cent of combustible from a pulverized-fuel installation. The average dust escaping the "thermix multicyclone," which amounted to 8.2 per cent of the total, was 11 microns with no particle coarser than 19 microns. The analysis of the combustible in the escaping dust was 15 per cent. This dust, according to Stokes' law, would travel approximately 8 miles in a 5-mile wind from the average stack. This was then compared with dust which averages 200 mesh and coarser. The combustible content in this case was 46.4 per cent against the average 22 per cent in the ash from the boiler. Even though all of this dust were 200 mesh, Stokes' law indicates that it would drop to the ground from the same height in less than 1000 ft of travel. Considering the quality of the material lost as the important point, fine dust constitutes the minimum from the nuisance standpoint. We feel that this point has been neglected in the past, but that, in the future, qualitative as well as quantitative dust collection will be borne in mind.

Of the two types of dust collector manufactured by the Prat-Daniel Corporation, the first is the "thermix recirculator," and the second is the "thermix controlled multicyclone." Briefly described, the recirculator is of the skimmer type and was the first of the type introduced in this country. The original installation was made in 1928 after 250 operating plants abroad were so equipped.

Skimmer-Type Dust Collectors

Dust collectors of the skimmer type have three essential parts. One is a circular passage in which the dust is concentrated toward the periphery, the second is the cutoff or skimmer opening along the periphery for withdrawing this dust plus a small percentage of gas, and the third is a cyclone for precipitating the concentrated dust in the gas with which it is withdrawn.

Since a certain amount of resistance must be overcome, a fan of some type is required and may be the induced-draft fan itself, or may be incorporated with the apparatus, as in the recirculator which also frequently acts as the induced-draft fan. The position of the fan wheel, in relation to the primary circular passage, is of considerable importance. If the fan is placed *before* the primary concentrator for the dust, the greatest suction in the entire system will, of course, be at the fan inlet. Any dust that escapes the secondary cyclone can, therefore, be brought back to the fan inlet and again passed through the primary concentrator.

If the fan is placed *beyond* the primary concentrator, the contrary will be true and without an auxiliary fan, the dust cannot be sent through the primary concentrator a second time. A more complete discussion of these two points, which have a serious influence on the degree of collection, is contained in an article[2] that was published recently.

The recirculator has the fan placed before the primary concentrator, thus allowing natural and normal recirculation from the cyclone to the primary concentrator a second time. To take some simple figures, assume that 90 per cent of the dust is concentrated in the primary passage and passed to a cyclone which is 80 per cent efficient. Without recirculation, the overall efficiency would be 0.8×0.9, or 0.72. With recirculation, according to the formula in the article mentioned, the collection would be 87.8 per cent. These percentages of concentration in the primary concentrator and collection in the cyclone can be varied in any desired combination but the fact is still evident that, with recirculation, a higher collection will result than without it, although not necessarily precisely the calculated theorectical amount.

The advantage of removing the dust before it reaches the fan blades would be of importance were it not that, in the recirculator where the fan is placed before the concentrator, cast wearing surfaces are placed on the fan blades, even with high-speed fans. These blades can be replaced without removing the wheel or the necessity for rebalancing when new blades have been installed. Approximately 50 per cent of the recirculators in the United States operate upon pulverized fuel and are doing entirely satisfactory jobs for the users, and the other 50 per cent operate upon stoker firing.

Utilization of Centrifugal Force in Dust Collection

However, to obtain the highest degree of collection with pulverized fuel which is frequently required in the central-station field, with an assurance that less than 10 per cent will escape, we generally advocate the use of the thermix controlled multicyclone. Basically, the formula for centrifugal force is mV^2/r, and the smaller the radius r is, the greater will be the centrifugal force. Furthermore, this force varies as the square of the velocity V of the gas.

To utilize this principle, the multicyclone is composed of a series of cast-iron cyclones approximately 2 ft in diameter arranged in parallel to insure high collection. Tests have shown that a 1-ft cyclone will increase collection approximately 2 per cent, but a 3-ft cyclone decreases collection approximately 2 per cent, and, for all practical purposes, a 2-ft cyclone gives sufficiently high collection in a limited space. For example, the gas from a boiler developing 100,000 lb per hr of steam can be handled in a ground area of approximately 220 sq ft or 110 sq ft if double-decked.

Two methods are used to maintain a constant velocity at varying loads. These methods are necessary because, if the load drops to one half the maximum designed load, the velocity will be one half and the centrifugal force one quarter. One method used is to decrease the number of cyclones in the circuit proportionately to the decrease in load, thus maintaining the collection constant at all loads. The other method is to partly close the dampers by utilizing a damper that throws the dust to the outside edge of the cyclone, thus mechanically compensating for

[1] President, Prat-Daniel Corporation. Mr. Whiton was graduated from Sheffield, Yale University, in 1912 and received a master's degree at Columbia University in 1913. His early experience was in connection with engineering problems for the recovery of waste products in the by-product coke-oven industry and later in the oil industry. He has been president of the Prat-Daniel Corporation since its inception in 1924. He is the author of numerous papers on the subject of induced-draft fans, heat-recovery devices, and particularly on dust collection from flue gases, in which he has specialized for the last ten years, holding a number of patents in that connection.

[2] "Recirculation in Skimmer Type Dust Collectors," by L. C. Whiton, Jr., *Power Plant Engineering*, vol. 40, 1936, p. 705.

lower centrifugal force due to lower velocity within the cyclone.

It would be impossible in this short paper to give fully results of the many tests which have been run to determine the efficiency of the thermix multicyclone. A typical example, however, is a test run some time ago under the supervision of and checked by three central-station engineers, using pulverized-fuel dust which had run 80.25 per cent through a 325-mesh screen. The overall collection efficiency at 400 F was 91.8 per cent. When operated at 70 per cent of the load the collection increased to 93.8 per cent due to the method of control used with this system.

To summarize, the recirculator, which overcomes its own resistance because of its fan, or which may act as an induced-draft fan, is important as a dust collector because of the recirculation principle. The multicyclone is the best development, of which we know, from the standpoint of extremely high collection with mechanical collectors. Both systems allow the least obnoxious type of material to escape when our attention is directed to the quality as well as quantity of dust that escapes, rather than having our attention concentrated only on the dust collected.

Riley Flue-Gas Scrubber

By O. CRAIG,[1] WORCESTER, MASS.

REMOVAL of fly ash from the gases passing up the chimney as a result of combustion is accomplished in the Riley flue-gas scrubber by causing the particles of ash to impinge on vertical carbon plates as the gas travels in staggered paths between the elements of the device. The surface of these plates which is exposed to the passage of the gas is kept wet, and this moisture causes the particles to adhere. The flow of water over the surface of the plates removes the accumulation of particles.

The construction of the scrubber is shown in Fig. 2. A series of flat carbon elements or plates, *A*, are arranged vertically in staggered formation between two horizontal tanks and two vertical side walls constituting a tunnel. Top tank *B* is a shallow, open reservoir into which water is fed at a constant rate through a pipe manifold *C*. Water, from the top of the tank, flows by gravity through metering orifices *D* into distributor boxes *E*. Elements are built in sections, each tied together rigidly with two lead-coated steel rods that are completely embedded in the carbon, and stand on the flat floor of the bottom tank *f*. The upper ends of the elements are guided by ribs *g* cast on the underside of the top tank. Elements are inserted through access doors *h* provided in the side walls of the housing. Five orifices *i* in each distributor discharge water over both surfaces of each element. Three orifices feed the surface facing the gas flow and two orifices feed the opposite side.

[1] Manager, engineering department, Riley Stoker Corporation. Mem. A.S.M.E. Mr. Craig was graduated from the University of Illinois in 1909 with the degree of B.S. in mechanical engineering and spent seven of the next nine years in teaching mechanical engineering at University of Colorado, Vanderbilt University, University of Texas, and Iowa State College. He spent one year, 1911–1912, as an assistant engineer at the United States Forest Products Laboratory, Madison, Wis., and conducted a research on timber seasoning, and for a year, 1914–1915, held the position of combustion engineer in the chain-grate department of the Laclede-Christy Clay Products Company, St. Louis, Mo. In 1918–1919, as mechanical engineer with the Charles L. Pillsbury Company, Minneapolis, Minn., Mr. Craig had charge of the operation of all State power plants under the State Board of Control; and the following year, he was engaged in perfecting processes for the utilization of powdered coal for the McLaughlin Coal Reduction Company, Decatur, Ill., as its chief engineer. Since 1920, when he received the degree of M.E. from the University of Illinois, Mr. Craig has been associated with the Under-Feed Stoker Company of America, Detroit, Mich., and the Riley Stoker Corporation, Worcester, Mass., as research engineer until 1936, and, since then, in his present capacity.

The gases travel in staggered paths between the elements *A*. In making changes of direction, the solid particles are thrown out of the path of the gases against the wet plates. These particles adhere to the moisture on the wet plates and are carried down by the water into the lower tank *f*. Water and solid particles collected in the lower tank are discharged through a manifold *j*, into a disposal system.

Corrosive acids are formed by the combination of scrub water and certain elements in the gases. This requires the selection of materials for construction which resist this corrosive action. Sides and the bottom tank are made of steel and are completely lined with acidproof tile laid in acidproof cement. Top tanks are made of cast iron with proper protection on the underside against direct attack of the flue gases. Parts most susceptible to corrosion are vertical elements or plates. These are made of extruded carbon, and long use indicates practically no deterioration.

Dust-Removal Efficiency. Efficiency of recovery expressed in percentage of dust loading is plotted against percentage of scrubber capacity in Fig. 1. Maximum scrubber capacity is equivalent to maximum boiler capacity. Rated scrubber capacity is usually chosen to correspond to what might be considered as a normal load on the boiler. At rated capacity, the velocity of gases entering the scrubber is approximately 1000 fpm. From 85 to 100 per cent of rated scrubber capacity, recovery is 90 per cent or more of dust loading. At half the rated capacity, recovery drops to about 75 per cent of dust loading.

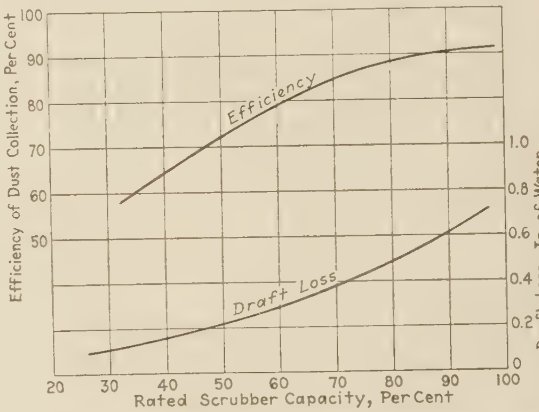


Fig. 1 Performance Curves Showing Dust-Removal Efficiency and Draft Loss With an Entering-Gas Velocity of 680 Fpm

Draft Loss Through Scrubber. The draft loss is also shown by a curve in Fig. 1. At rated capacity, this is approximately 0.8 in. of water and at half of rated capacity, approximately 0.2 in.

Drop in Flue-Gas Temperature. Due to contact with cold wash water, the temperature of gases leaving the scrubber is less than that at entering. Experience has shown that with water entering the scrubber, at 60 F, the drop in flue-gas temperature varies from 120 to 250 F, corresponding to inlet-gas temperatures of 350 to 600 F, respectively. Reduction in gas volume due to decreased gas temperature compensates for the draft loss through the scrubber, so that the same size of induced-draft fan is still suitable, and the power required for this fan remains practically the same.

Water Requirements. Standard practice is to supply water at the rate of $2^1/_2$ gal per 1000 cu ft of flue gas at the maximum scrubber rating and to maintain the water supply constant regardless of variations in load. This corresponds to approximately 6 lb of water for each pound of coal burned at maximum boiler capacity.

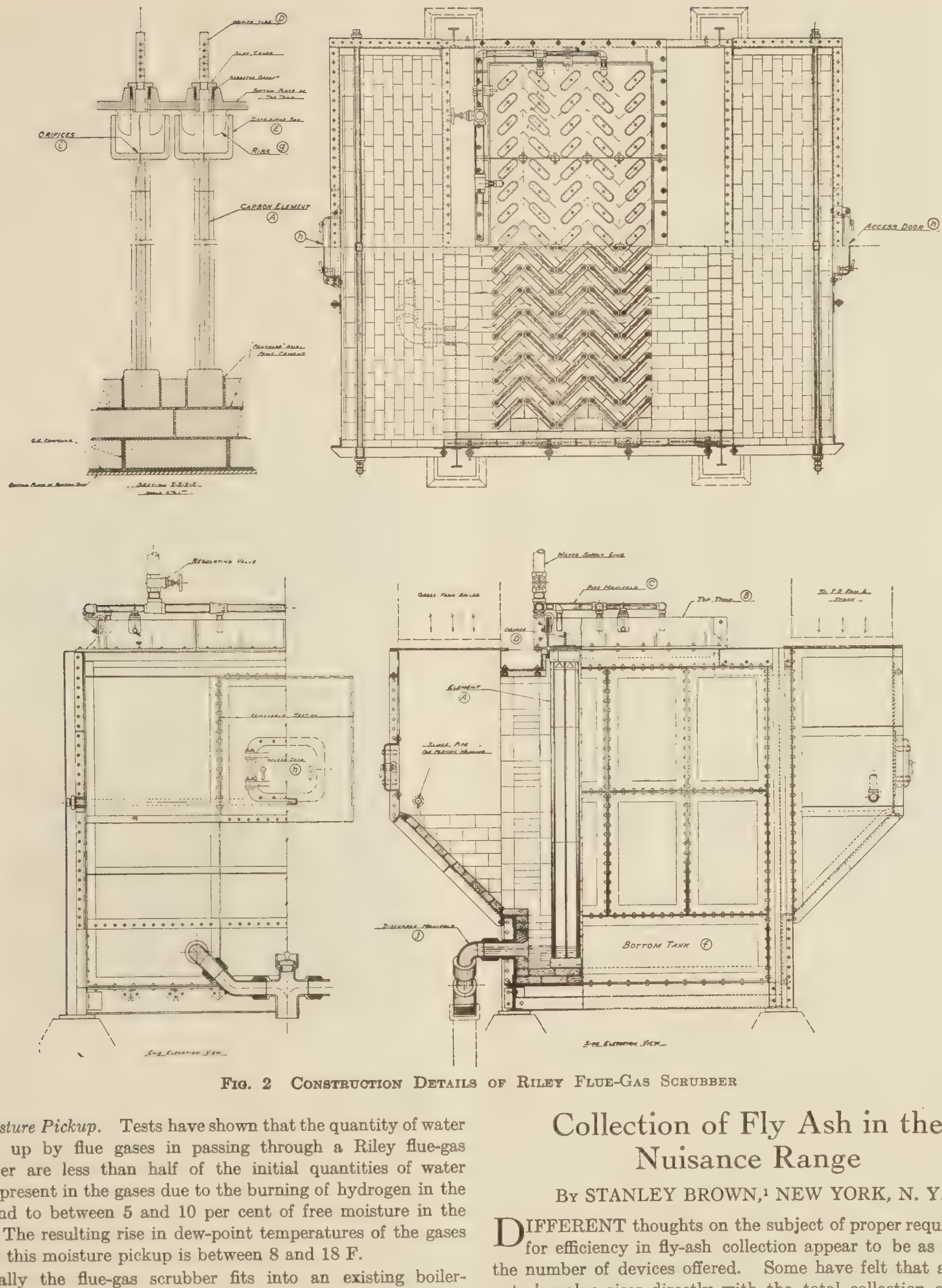


Fig. 2 Construction Details of Riley Flue-Gas Scrubber

Moisture Pickup. Tests have shown that the quantity of water picked up by flue gases in passing through a Riley flue-gas scrubber are less than half of the initial quantities of water vapor present in the gases due to the burning of hydrogen in the coal and to between 5 and 10 per cent of free moisture in the coal. The resulting rise in dew-point temperatures of the gases due to this moisture pickup is between 8 and 18 F.

Usually the flue-gas scrubber fits into an existing boiler-plant design readily. In one particular case, the scrubber is on the same floor as the induced-draft fan. The gases pass through the boiler, an air heater, then through the scrubber and into the induced-draft fan. The space which is occupied by the scrubber is approximately that occupied by the induced-draft fan.

Collection of Fly Ash in the Nuisance Range

By STANLEY BROWN,[1] NEW YORK, N. Y.

Different thoughts on the subject of proper requirements for efficiency in fly-ash collection appear to be as many as the number of devices offered. Some have felt that an eliminator's value rises directly with the total collection efficiency which it exhibits. However, according to a reasonable sizing

[1] Buell Engineering Co., Inc. Mr. Brown was graduated from the electrical-engineering course of Columbia University in 1902. He served for one year with the Cornell Iron Company on structural-steel work and for two years with Peet and Powers on electrical contracting. He was resident manager of the New York office of

acceptance as defining the lower end of the nuisance range, the following thought is of interest. An overall collection efficiency of 90 per cent might be secured by catching exactly 90 per cent of all particles of various sizes, while a device having an overall efficiency of 80 per cent might actually possess an average collection efficiency of 95 per cent throughout the nuisance range, and, if so, this would be preferred.

We do not have to turn many pages in the power-plant history to find a parallel with the present progress in fly-ash collection achievement. With the awakening of wisdom in "heat balance," strife raged through several years as to which plant could show the highest efficiency in British thermal units per kilowatthour. But it was soon evident that efficiency is of primary interest only when referred to the proper denominator, or shall we say when referred to the proper size of particles, which particles, in power development, are the dollars per 1000 kwhr.

Greater Size Consciousness Needed

So let us think together wisely. What is required?

If we consult our brothers on the Continent where there are many times the number of fly-ash eliminators that have been installed in the United States, we find the following reply: "In about May of this year, the imposed requirement for avoiding fly-ash nuisance was carefully refined to the specification that the collector must catch 90 per cent of all particles of 30-micron [1μ = 0.001 mm = 0.000039 in.] size, submesh 500, and larger."

In this regard, Dr. Otto Schoene, a professor at Charlottenburg University, who has had extremely broad experience in fly-ash study, states that if a fly-ash eliminator could accomplish a 90 per cent collection efficiency for all particles of 20-micron size and larger, the result would be beyond criticism.

Are we sufficiently "size conscious?" The smallest size of particle that is usually observed by unaided eyesight, with 12 ft-c of illumination, is approximately 35 microns (submesh 450).

Finely ground cosmetic powders of the "air-spun" variety, which are prepared in special micronizers, comprise particles having a size of about 27 microns (submesh 530).

Let us now give a moment to the consideration of falling time as related to particle size, and assume the moderate stack height of 150 ft with sufficient discharge velocity from the stack to carry the particles another 50 ft. Table 1 gives data on the falling time in still air from a height of 200 ft. In a separate column is indicated the distance that the particles of various size would travel before traversing the vertical distance of 200 ft when subjected to a breeze of 5 mph. Weather statistics report that, at a height of 200 ft from the ground, air motion of less than 5 mph is rare.

TABLE 1 TIME OF FALL AND DISTANCE TRAVELED BY VARIOUS SIZES OF PARTICLES

Sizing of fly-ash particles Microns	Submesh	Time to fall 200 ft in still air, hr	Travel (in 5-mph breeze) while falling 200 ft, miles
20	625	0.715	3.58
10	1250	2.40	12.00
5	2500	9.20	46.00
2	6250	85.60	428.00

A significant element within the term "nuisance" is the percentage of combustible in the fly-ash particles. Since this content greatly increases with the increase of particle size, the wisdom of attacking the "offenders" that are the most objectionable is apparent. If the dust has a value, catching it in terms of total-collection efficiency is worthy of consideration. Whereas, if the dust is merely annoyance, let us deal directly with the nuisance range.

the Weston Electrical Instrument Company for 11 years; and for 17 years was sales manager with Griscom-Russell Company. He also spent two years in miscellaneous research. He has been with the Buell Engineering Company for two years as director of the dust-collection division.

Design and Performance of Buell Eliminator

And now a few words on the Buell eliminator (van Tongeren system) which, according to the known performance of approximately 90 fly-ash installations, is offered to give proper battle against "fly-ash nuisance." Fig. 1 illustrates the compound type of dust eliminator, comprising a concentrating chamber and a cyclone. The total gas to be cleaned enters the chamber, the dust seeks a position adjacent to the volute casing, and is shaved off with between 10 and 15 per cent of the total gas for actual collection in the cyclone.

Fig. 2 again shows the compound type of eliminator and indicates the double-eddy current flow in the concentrating chamber and in the cyclone. In both instances, the influence is outward at the meeting of the eddy-currents, and the cleansed gas is discharged at this zone.

The cyclone is different from the earlier art in (*a*) low position of gas inlet to the top cylinder, (*b*) low position of the mouth of

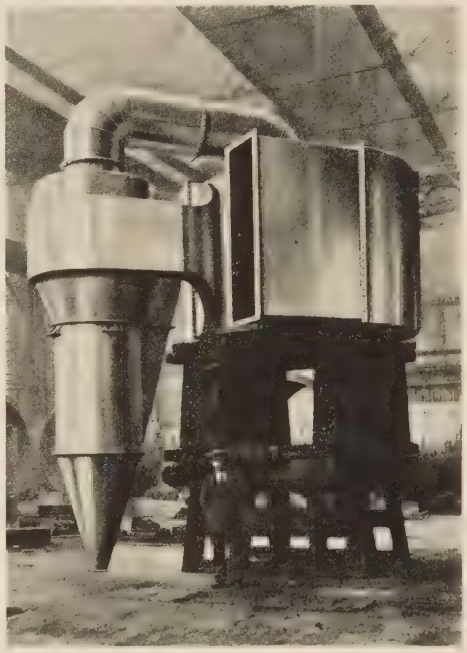


Fig. 1 Compound Type of Buell Dust Eliminator

the outlet pipe, (*c*) by-pass dust channel, and (*d*) increased ratio of overall height to a diameter of top cylinder.

Providing these features in the design gives a dust-concentration space above the gas inlet and permits a steady shaving off of dust from this zone for by-passing through the outside dust channel, which is located away from the mouth of the outlet pipe. This dust reenters at the mid-cylinder and the downward flow of the lower half of the double-eddy current promotes the travel of this dust to the bottom dust outlet.

Fig. 3 is a performance curve expressing the relation between particle size of fly ash and collection efficiency. This has been developed from reports of independent engineers who were retained by purchasers in connection with acceptance tests and includes eliminators having unit capacities as high as 118,000 cfm. As collection efficiencies ranging from 90 to over 93 per cent have been reported for particles of the 20-micron size and similar

values of between 82.4 and more than 86 per cent have been reported for the 10-micron sizing, the values shown on the curve are conservative. Many tests showed average collection-efficiency variations of less than 0.4 per cent for the various particle sizes according to the character of combustion origin, whether pulverized coal, stoker-fired coal, or stoker-fired lignite. These efficiencies were attained with a draft loss of less than 1.6 in. of water and a gas temperature of 400 F. With the knowledge that this eliminator has readily collected 90 per cent of the 20-micron size particles, a guarantee, as suggested by Dr. Schoene,

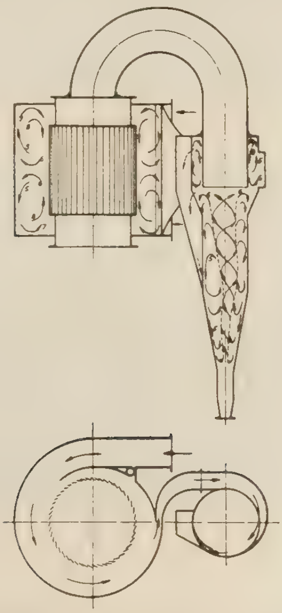


Fig. 2 Establishment of Double-Eddy Current Flow in the Concentrating Chamber and the Cyclone

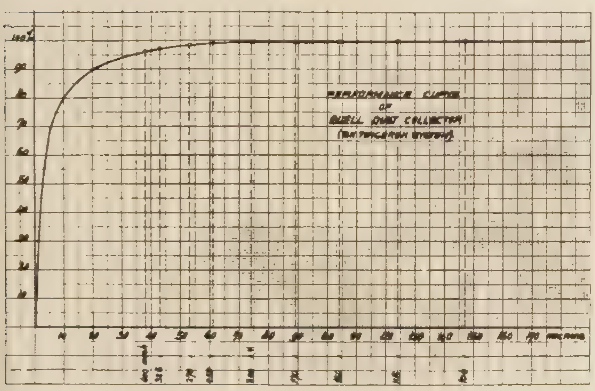


Fig. 3 Performance Curve Based on a Number of Acceptance Tests by Independent Engineers

regarding the collection of 90 per cent of all particles of 20-micron size and larger would be easily fulfilled.

Fig. 4 gives additional data of interest relating to the cyclone collector of the Buell system. These two curves relate to cyclones of similar design, with the exception that the cyclone represented by the lower curve has no dust by-pass system, whereas the

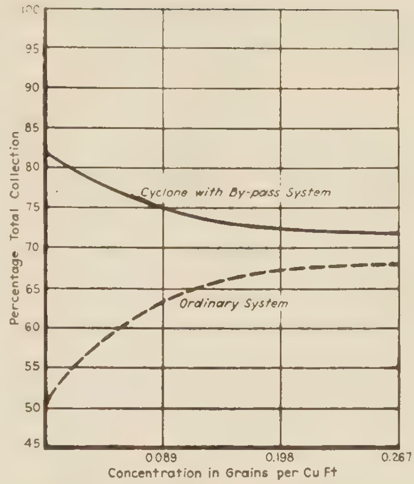


Fig. 4 Comparison of Collection Efficiency of Two Different Types of Cyclone at Various Dust Concentrations

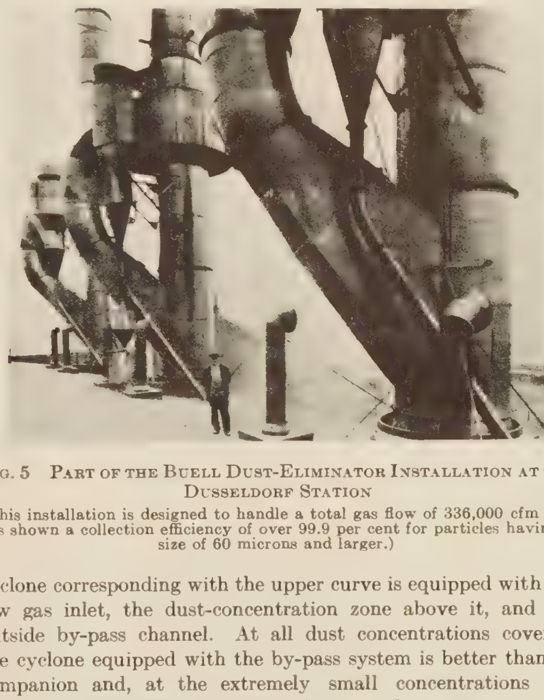


Fig. 5 Part of the Buell Dust-Eliminator Installation at the Dusseldorf Station

(This installation is designed to handle a total gas flow of 336,000 cfm and has shown a collection efficiency of over 99.9 per cent for particles having a size of 60 microns and larger.)

cyclone corresponding with the upper curve is equipped with the low gas inlet, the dust-concentration zone above it, and the outside by-pass channel. At all dust concentrations covered, the cyclone equipped with the by-pass system is better than its companion and, at the extremely small concentrations the efficiency characteristic is distinctly upward.

Fig. 5 shows part of the installation at the Dusseldorf station, which has a total of six collectors for an overall gas flow of 336,000 cfm. An independent engineering report on this station cited a collection of more than 99.9 per cent for all particles of 60 microns, approximately 250 mesh, and larger. This being a stoker-fired plant, the extremely small micron sizings were not considered of importance in the test.

In the matter of selective elimination, if the extreme fines are unnecessarily collected, the expression "What are we going to do with it after we catch it" is only magnified. In conclusion, the value of an eliminator should be rated directly in terms of its ability to collect the ash within the nuisance range.

Utilization of Pulverized-Fuel Fly Ash

By J. R. JAMES,[1] DETROIT, MICH.

THE TRENTON Channel plant of The Detroit Edison Company accumulates approximately 500 tons of fly ash per week by Cottrell precipitators. For the last several years, this company has carried on a number of investigations to find a method that would return at least enough revenue to pay for the handling of the ash on the property. Today, two outlets indicate considerable promise. One of these is what may be called a new kind of concrete, and the other is the manufacture of a building unit that is designated as Cottrell block.

The new concrete is made by mixing 100 lb of portland cement, 100 lb of dry fly ash, and approximately 340 lb of crushed cinders with the proper quantity of water. In 28 days, the resulting concrete shows a strength in compression of 3000 lb per sq in. To be conservative, the cost of this concrete will not be more than the ordinary stone or gravel concrete, and probably it will be slightly less. The real benefit to be derived from its use will be the reduction in the weight of a building which is reflected in reduced costs in foundation work. At present, no detailed practical information about this concrete is available, but The Detroit Edison Company plans to use it in the floor system of a six-story office building that will soon be built, so that, six months from now, some authentic information regarding this material will have been secured.

Our company has been developing Cottrell block for over three years under a patent controlled by the Rostone Company, Lafayette, Ind. This development work was carried on in a small plant with standard-size equipment which was set up in the basement of the Trenton Channel plant boiler room. Progress of this development has centered principally about the construction of a suitable machine for making these blocks as a commercial article. The estimated cost of a new plant manufacturing 8600 units in 24 hr is approximately $40,000.

Disposal of fly ash would be facilitated by using both of these outlets in conjunction with each other. The natural assumption is that the maximum volume of concrete will be poured in the warm months of the year, which leaves the winter months for the manufacture and accumulation of building blocks for the ensuing year's construction.

The overall heat-conductivity coefficient for an 8-in. wall of this material, in a 15-mph breeze, is 0.383 Btu per sq ft per hr per deg F difference in temperature. If the wall is furred and plastered on the hot side, the coefficient becomes 0.26. When hollow cells are filled with rock wool, the coefficient is 0.16, and by substituting fly ash, the coefficient is 0.18. In a fire test conducted at the Delray plant, a wall of Cottrell block was subjected to a 3-hr fire test, with 1600 F as the maximum temperature and then quenched with a fire hose, without destroying its structural value. However, some small shrinkage cracks about 1/8 in. deep did develop. Absorption will run about 6 per cent.

Fig. 1 Interior of a Church That Was Built of Cottrell Block

Fig. 2 Exterior of a House Built of Portland Cement Painted Cottrell Block

At the Trenton Channel plant is a garage which was built over three years ago. No ill effect from frost action can be observed. Numerous other structures have been built with Cottrell block. Fig. 1 is an example of a painted Cottrell block interior. The large home, shown in Fig. 2, has an exterior of portland cement painted Cottrell block. Smaller homes have 8-in. Cottrell block walls painted on the outside and a painted interior. The cells in the block are filled with ash. As the owners are well satisfied with the purchase price of $3500, including two acres of land, this block should appeal to low-cost housing projects.

[1] Senior engineer, civil- and mechanical-engineering design, The Detroit Edison Company. Mem. A.S.M.E. Mr. James received the degree of C.E. from the University of Michigan in 1911 and, for the next eight months, was principal assistant on a magnetic survey of the Great Lakes for the U. S. Lakes Survey. He was engaged in the design of hydroelectric projects for Gardiner S. Williams, Ann Arbor, Mich., for the next year and, in this connection, acted as field-construction supervisor for the 1500-kw Argo plant of The Detroit Edison Company. From January, 1913, until April, 1914, Mr. James was in charge of appraisal of overhead lines for the Eastern Michigan Edison Company, which company merged with The Detroit Edison Company in 1916. Upon the completion of this work, he accepted a position of draftsman with his present company, being promoted to engineer and assistant draftsman and, in 1925, became senior engineer in the engineering division.

The Cinder and Fly-Ash Public Nuisance

By WILLIAM G. CHRISTY,[1] JERSEY CITY, N. J.

THOSE of us, who are interested in the problems of air pollution, are glad to see discussions such as this on the programs of the A.S.M.E. We are also pleased to see the increased interest in this question. Use of pulverized coal, increase in the

[1] Hudson County smoke-abatement engineer. Mem. A.S.M.E. Mr. Christy received the degree of M.E. from Cornell University in 1911 and spent the next year with the Heine Safety Boiler Company as a designing, estimating, and testing engineer. From 1912 to 1915, he was assistant to H. H. Humphrey, consulting engineer at St. Louis, Mo., where he prepared plans and specifications for power plants, heating and ventilating systems, and mechanical and electrical equipment for office buildings, hospitals, hotels, factories, and similar structures. For the next two years, he conducted a manufacturers' agency in St. Louis, and handled heating specialties and power-plant

size of stokers, and greater rates of burning solid fuel have resulted in a tremendous increase in the discharge of solids from stacks in recent years. The public is demanding that something be done.

Suitable Means for Accurate Cinder Measurement Urgently Needed

Primarily a need exists for suitable means of accurately measuring the percentage of cinders and fly ash in a gas stream. Our Power Test Code Technical Committee on Dust Separating Apparatus is now working on this problem and hopes to establish standards for both measuring and testing. The problems of measuring solids in gas streams and testing equipment for their removal really come down to determining the best methods of obtaining representative samples. The time is now here when legislation and regulations, defining and limiting the discharge of solids from chimneys, are likely to be adopted. Such requirements should be reasonable. They should give the public relief and at the same time not cause too much hardship on industries and utilities.

The Smoke Prevention Association is a national organization of smoke commissioners, smoke inspectors, railroad men, and others interested in fuel economy and smoke abatement. At present, the Public Service Committee and the Standards Committee of this organization are working on the problem of establishing standards of measuring and regulating the discharge of cinders and fly ash into the atmosphere. I feel sure that I voice the sentiments of the members of the Association when I say that we would welcome the cooperation of this Society.

Not much legislation on this subject exists at present. Some ordinances prohibit excessive discharge of fly ash and cinders and some of these specify that such solids be measured by the Ringelmann chart. This chart was really not intended for measuring fly ash and is not suitable for that purpose. Other ordinances classify excessive discharge of solids from stacks as a nuisance, but this is also unsatisfactory. Such a regulation is subject to different interpretations.

Cinder Deposits a Nuisance and Possible Cause of Damage

It should be needless for me to emphasize that the deposit of cinders and fly ash is a nuisance and may cause considerable damage. Some two years ago, I had occasion to investigate the discharge of fly ash from a plant fired with pulverized coal. The principal complainant was a truck farmer, whose farm was approximately one-half mile east of the plant. Apparently, his crops were being ruined by the excessive deposit of fly ash due to the prevailing winds from the west. Along the edge of some timber was land that had not been cultivated. In this location, I saw a deposit of fly ash $2^1/_2$ in. thick, the worst I have ever seen. The deposit was the result of some seven or eight years' operation of the plant. A corporation, whose officials have any civic pride, should want to reduce materially such a discharge, irrespective of any legislation.

My hope is that discussions such as this and the work of the A.S.M.E. Power Test Code Committee No. 21 will enable us to arrive at a basis for sane legislation. Surely, all of us agree that something must be done. Mechanical engineers ought to make this their responsibility. Otherwise, legislation may be passed which is not based on engineering practice, is impractical, or may work undue hardships.

Fly-Ash Removal and Smoke-Abatement Problems Demand Solution

From the standpoint of the public, this problem is one that must be solved. With powdered-coal plants, some sort of fly-ash removal apparatus is surely necessary. I feel that the time is not far distant when most stoker-fired boilers and furnaces will have flue-gas scrubbers or cinder catchers.

The term "smoke abatement" is really a misnomer; it means much more than the elimination of visible smoke. The name "Pure Air" which was used to designate the A.S.M.E. committee always appealed to me. Smoke-abatement engineers are interested in eliminating all kinds of air pollution and really getting pure air to breathe. It is much more than a question of good combustion. It means a drastic reduction of fumes, sulphur gases and solids from stacks and open fires.

---

equipment. From 1918 to 1920, he was associated with the U. S. Shipping Board, first as a production engineer and later as a district supply manager. From 1920 to 1922, he was superintendent and field engineer of the St. Louis Boat and Engineering Co., having charge of the construction of four large Mississippi River towboats. He then became associated with F. H. Schubert in the Schubert-Christy Construction and Machinery Co. of St. Louis. While Chairman of the St. Louis Section, A.S.M.E., in 1925, he was one of the organizers of the Citizens Smoke Abatement League of St. Louis, and served as its executive secretary for two years.

Determination of the Relative Resistance to Cavitation Erosion by the Vibratory Method

By S. LOGAN KERR,[1] PHILADELPHIA, PA.

The cavitation-erosion tests described in this report were made under the direction of the mechanical section, U. S. Engineer Office, Eastport, Me., at the Massachusetts Institute of Technology, Cambridge, Mass., by Prof. H. Peters. The investigation was part of the materials-corrosion investigation, made to provide an accurate basis for the selection of the proper materials to be used in the construction of the large hydroelectric units required on the Passamaquoddy project. No information was available upon the cavitation resistance of materials in sea water as compared with their behavior in fresh water. The program included tests on 80 materials in a newly developed vibratory apparatus and the behavior of three materials in the venturi-type apparatus used for previous investigations. Reliable results were obtained on the behavior of materials in sea water as compared with fresh water, and the relation between cavitation damage and temperature was established.

ONE OF the most troublesome of the operating difficulties encountered with hydraulic turbines or centrifugal pumps has been pitting or eroding action caused by cavitation on blades and other portions of machinery subjected to high-velocity flow. Research investigations on this phenomenon have followed two separate lines

(1) Effect of cavitation upon efficiency or performance
(2) Destructive effects of cavitation upon materials

The *first* group covers elements which are functions of turbine or pump design, and the responsibility rests quite properly with the manufacturers to insure against faulty performance due to cavitation. If model turbines or pumps are constructed and tested under varying conditions of draft head or suction lift, the characteristics of those particular types can be established and information secured which governs the design of the structures in which they are to be installed. Many articles have been published recently describing the general theory of cavitation and the testing of laboratory models.

The *second* group dealing with relative rates of erosion of various metals by cavitation has also been the subject of some research. A limited volume of test information is available in regard to the behavior of various materials in fresh water, but no data could be found which gave the damage from cavitation in sea water as compared with that experienced in fresh water.

It has been found from experience that, in localized areas, cavitation can be set up which is not of sufficient magnitude to reduce the efficiency or to affect the performance of the unit but is sufficiently intense in many cases to cause destructive pitting on the blades or throat rings and to require maintenance at frequent intervals. The cost of maintaining and repairing large units and the loss of output during the repair period make it essential that suitable erosion-resisting metals be employed in the portions of the turbines where high velocities and potential cavitation damage might be found.

Purpose of the Investigation

In connection with the Passamaquoddy Tidal Power Development at Eastport, Me., a materials-corrosion investigation[2] was instituted to select the materials suitable for use in the various structures and equipment exposed to the action of sea water or salt air. In this investigation, three principal factors were considered

(1) Corrosion of metals in sea water
(2) Electrolytic action between dissimilar metals in sea water
(3) Resistance of various metals to the erosive action of cavitation

Only the third phase of the investigation is covered in this article, the results of the first and second portions are not yet available as the exposure tests are being continued until June 30, 1937, at least. From the information secured in this investigation, it was expected that the materials for constructing the turbines, gates, and other portions of the equipment could be selected to give the longest life at the least cost.

Definition of Cavitation Action

For many years, pitting on the suction side of hydraulic-turbine runners and of pump impellers was thought to be due to a chemical action which resulted from the release of dissolved oxygen in the water. Investigations made in England with marine propellers some years ago indicated that the action was mechanical rather than chemical and that it was caused by a rapid fluctuation of pressure due to the repeated formation and collapse of vacuum pockets adjacent to the blades.

With cast iron, this action proceeds very rapidly, as the material is naturally porous, the softer portions are eaten away, and

[1] Manager, Chemical Engineering Division, United Engineers & Constructors Inc., Philadelphia, Pa. Mem. A.S.M.E. Mr. Kerr was graduated from the University of Pennsylvania in 1921 with the degree of B.S. and, in 1924, with degree of M.E. Upon graduation, he entered the I. P. Morris Division of the William Cramp & Sons Ship & Engine Building Co. as research assistant. In 1924, he was appointed assistant hydraulic engineer and, in 1927, assistant chief engineer. From 1929 to 1935, he was research engineer in charge of experimental and field tests and development work on hydraulic turbines, governors, valves, and other equipment. In 1935 and 1936, he was senior mechanical engineer, U. S. Engineer Office, Eastport, Me., having charge of research and design work in connection with the mechanical equipment for the Passamaquoddy project. At present he is in the Chemical Engineering Division of United Engineers & Constructors Inc., Philadelphia, Pa. Mr. Kerr is 1936–1937 Chairman of the A.S.M.E. Hydraulic Division and of the A.S.M.E. Committee on Water Hammer.

Contributed by the Hydraulic Division and presented at the Joint Meeting of the Applied Mechanics and Hydraulic Divisions of The American Society of Mechanical Engineers, Ithaca, N. Y., June 25–26, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until September 10, 1937, for publication at a later date.

[2] For description of the investigation, scope of studies, laboratory facilities, and results of tests, see Interim Reports of U. S. Engineer Office, Eastport, Me., dated Feb. 15 and Oct. 15, 1936.

the harder sections remain, giving the characteristic "pitted" appearance. With cast steel, the action is much the same, but, due to the higher fiber strength and denser structure, it does not proceed as rapidly. With cast bronze, the grain structure is also dense and, although the pitted appearance is not as pronounced, the vanes have a sandblasted appearance where cavitation is present.

With alloy steels of high strength and extremely dense grain structure, the resistance to cavitation damage has been found to be very high, but these materials are extremely expensive and are difficult to secure in the cast form.

Methods of Test

Accurate determination of the relative resistance of materials to cavitation erosion presents many difficulties, as the rate of erosion experienced in the field is slow and operating conditions vary considerably. Testing of model turbines constructed of

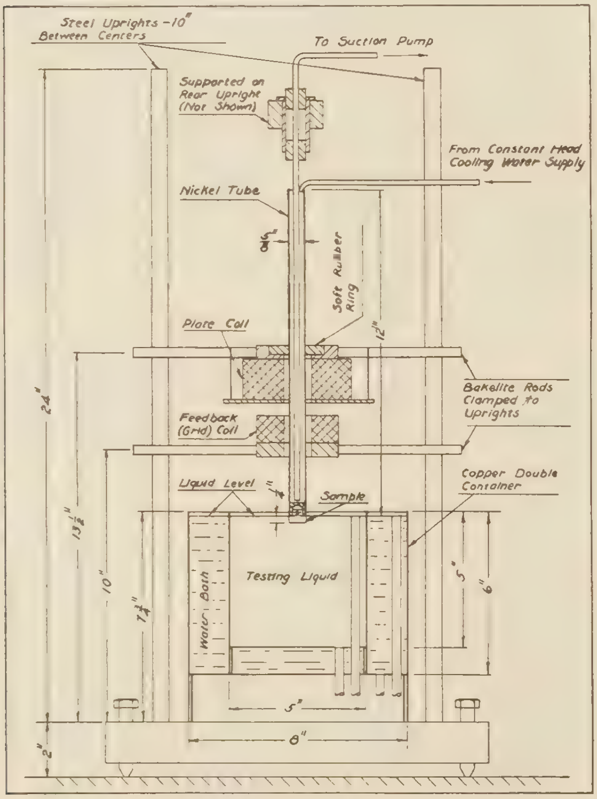


Fig. 1 Vibratory-Type Cavitation-Testing Apparatus

different metals does not appear to be feasible due to the cost involved. Cavitation action of great intensity can be produced in the laboratory by passing water at high velocity through a restricted area followed by a more or less sudden enlargement. Early types of cavitation-testing apparatus were in the form of a venturi tube, and this name is generally used to designate that type of test unit, although newer and more efficient throat profiles have been developed in the United States and Europe.

The first experimental unit of the venturi type in the United States was constructed in the Massachusetts Institute of Technology, and a second unit added a short time thereafter. The Safe Harbor Water Power Corporation sponsored this work, and it has since set up similar venturi testing units at Holtwood, and Safe Harbor, Pa. Results of this investigation are given in the paper[3] by J. M. Mousson.

Had this method been employed in the investigation for the Passamaquoddy project, a minimum period of one year would have been required to test about 50 different materials, one specimen being tested in fresh water and one in sea water. The time available for this experimental program, based upon the tentative construction schedule, was only a few months, and a more rapid method was required.

In the spring of 1935, investigations had been under way at the Massachusetts Institute of Technology utilizing a somewhat different method of cavitation testing, as shown in Figs. 1 and 2, whereby the metallic sample was vibrated at high frequency to simulate a very intense local form of cavitation. By the summer of 1935, this had progressed to the point where Dr. J. C. Hunsaker and Dr. H. Peters of the mechanical-engineering department of Massachusetts Institute of Technology felt that reasonably accurate results could be secured on the relative resistance of various materials to cavitation erosion.

The vibratory apparatus, Fig. 1, consisted of a vacuum-tube oscillator used for producing an alternating magnetic field in which was placed a nickel tube that vibrated longitudinally at its natural frequency under the action of this magnetic field.

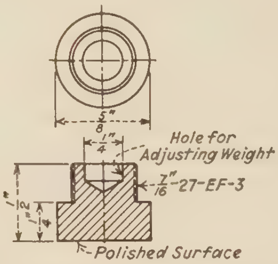


Fig. 2 Vibratory-Type Test Specimen

The specimens were attached to the end of the nickel tube and were immersed in the test fluid, care being taken that the depth of immersion was maintained constant at $^1/_4$ in. The test container was set in a water bath to maintain a constant temperature throughout. The nickel tube was cooled by a fine spray of water which was withdrawn from the bottom of the tube by a small suction pump.

This vibratory apparatus was developed by Dr. Newton Gaines and is described in his article[4] entitled, "A Magnetostriction Oscillator Producing Intense Audible Sound and Some Effects Obtained." A description of its use for cavitation testing is given by Dr. J. C. Hunsaker in his paper[5] "Progress Report on Cavitation Research at Massachusetts Institute of Technology."

In the fall of 1935, the method was investigated by the writer for the U. S. Engineer Department, and preliminary tests were found to be sufficiently reliable for the determination of the relative resistance of these various materials to cavitation.

While this new vibratory method had never been utilized previously for any extensive commercial research or investigation programs, a detailed study of the apparatus and of preliminary test results indicated that results could be duplicated accurately, the time element for the complete investigation could be reduced to a few months, and the cost of operation was about one tenth

[3] "Pitting Resistance of Metals Under Cavitation Conditions," by J. M. Mousson, to be presented at the Joint Meeting of the Hydraulic and Applied Mechanics Divisions of The American Society of Mechanical Engineers, Ithaca, N. Y., June 25–26, 1937.

[4] *Physics*, vol. 3, 1932, pp. 209–229.

[5] Trans. A.S.M.E., vol. 57, 1935, pp. 423–424, paper HYD-57-11.

to one fifth of that estimated for the normal venturi method. The vibratory apparatus also had the unique advantage that the fluid could be changed readily, permitting a careful study of the relative damage in fresh and sea water.

A contract was arranged between the U. S. Engineer Office at Eastport, Me., and Massachusetts Institute of Technology to cover the testing of a number of specimens by the vibratory method and to check the relative results obtained in this manner with tests of a limited number of the same materials in the venturi apparatus at the Institute for previous research work.

Preliminary Tests

With such a new method of test, careful calibrations were essential. Maximum and minimum rates of weight loss, design of specimen, proper length of exposure, and many other problems immediately presented themselves. Preliminary tests demonstrated at once that results were remarkably consistent, temperature and type of solution had a marked effect upon rate of erosion, and many materials behaved differently at the outset of the test period from what they did after an appreciable time of exposure.

Four materials supplied by the Institute were used in these calibrations, namely, brass, cold-rolled steel, cast iron, and stainless steel. Two specimens of each material were tested for 2 hr, with weight losses determined at the end of each half-hour during the test. Fig. 3 gives the results of these tests. It was found that the test period could be reduced to 90 min, with intermediate weight determinations at the end of each 30 min of exposure.

Some changes in apparatus were necessary, but after a few disappointing experiences, the equipment was arranged to operate continuously from 8 a.m. to midnight, employing two shifts of observers. The first tests were made in March, 1936, and the program was completed July 15, 1936.

Methods of Securing Samples

Various manufacturers of turbines and pumps, as well as a group of foundry companies and other organizations, had already been approached in regard to the materials-corrosion investigation, and corrosion-test specimens for the Eastport laboratory had been secured from most of these organizations. A special information circular, dealing entirely with cavitation-resistance tests, was prepared and forwarded to manufacturers about Dec. 14, 1935. A brief description of the vibratory method was given, and a request for cavitation-test specimens was made of all organizations which had furnished corrosion specimens for the Eastport laboratory.

Response to this inquiry was very satisfactory, and 98 different materials were submitted for test. Funds were available for testing only 50 of the specimens submitted, and it was necessary to establish a priority list that included only those materials which had already been submitted for corrosion tests. From these were selected first, the materials submitted by turbine manufacturers; second, those submitted by pump manufacturers; and third, special materials deemed necessary to cover the field satisfactorily. It was later found possible to test 80 different materials and conduct additional tests to determine the effect of temperature, different concentrations of salt water as compared with natural sea water, and the protection afforded by noncorrosive coatings.

To simplify comparisons and to divide the large number of materials into groups, a classification was set up applying to the corrosion testing as well as the cavitation testing. The classifications used and the number of specimens in each class are given in Table 1.

Each different material was assigned a serial number, and each individual specimen had an identifying letter or a combination of letters and numbers to coordinate the records and keep the identity of the manufacturer confidential. Trade names have been eliminated from the records, and, for certain materials, only the approximate composition is given, although, in most cases, the certified chemical analysis is published. Written permission was obtained from each manufacturer for the release of data pertaining to his materials to be included in the published reports of the tests.

In the check tests by the venturi method in both salt and fresh water, three materials, cast iron, class 10, serial 82; cast steel, class 13, serial 118; and manganese bronze, class 5, serial 76, were selected. An additional test was made in fresh water only with a chrome-nickel steel, class 17, serial 132. No venturi test

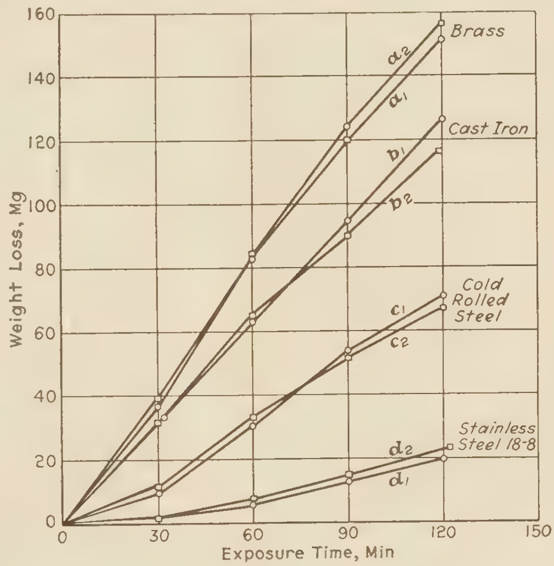


Fig. 3 Preliminary Calibration-Test Curves
(Weight of sample = 13 g; water temperature = 20 C.)

was possible on this material in sea water owing to lack of time and of funds.

Specimens

The design of the vibratory-test specimen was investigated very carefully, and five different brass specimens, varying in weight from 8 to 16 g, were tested. It was found that the total weight loss at the end of 30 min was practically the same, irrespective of the initial weight. The convenient value was found to be about 13.5 g and all specimens were adjusted to fall within 1 g above or below this weight.

As shown in Fig. 2, each specimen was $^5/_8$ in. in diameter and $^1/_4$ in. long with a threaded extension $^7/_{16}$ in. in diameter and $^1/_4$ in. long which was used to attach the specimen to the oscillating nickel tube. A small hole, $^1/_4$ in. in diameter, was drilled in the threaded end of the specimen to adjust the weight to the standard range and thus compensate for differences in densities of material. The face was carefully polished to secure as uniform a surface as possible for exposure to cavitation. These specimens were prepared in the machine shop at the Massachusetts Institute of Technology. Six specimens of each type were normally available, although, in most cases, only four specimens were prepared unless special tests were called for.

Test Procedure

The general procedure consisted in setting up a dummy specimen which would oscillate for approximately 15 min to bring the

TABLE 1 LIST OF MATERIALS UNDER TEST, ARRANGED BY ORDER OF WEIGHT LOSS AND CLASSIFICATION (NONFERROUS)

Serial no.	Material	Form	Scale 1 — Fresh water	Scale 1 — Sea water	Physical properties — Tensile strength, lb per sq in.	Physical properties — Yield strength, lb per sq in.	Physical properties — Elongation, per cent	Physical properties — Hardness Rockwell B	Chemical analysis, per cent — Copper	Tin	Zinc	Manganese	Silicon	Nickel	Iron	Lead	Aluminum	Weight loss at 25 C, mg — Fresh water First 30 min	Fresh water Last 60 min	Sea water First 30 min	Sea water Last 60 min	Serial no.
Class 1, Brass or Bronze																						
10	Bronze (Cu-Zn-Sn)	Rolled	1	1	67,000	36,400	35	67.7	60	1	39	...	...	..	...	..	...	28.6	69.5	22.5	65.2	10
154	Bronze (Cu-Zn-Sn)	Rolled	2	2	60,000	27,000	35	76.4	60	1	39	...	...	..	...	..	...	25.3	70.4	26.2	68.3	154
18	Brass (Cu-Zn-Sn)	Rolled	3	4	71,200	50,400	36	67.5	60	1	39	...	...	..	...	..	..	28.3	72.3	25.6	74.1	18
8	Brass (Cu-Zn)	Rolled	4	3	73,000	49,000	..	70.0	60	..	40	...	...	...	...	..	...	34.3	77.8	25.2	68.7	8
16	Brass (Cu-Zn)	Rolled	5	5	49,600	46,600	60	53.7	85	..	15	...	...	..	...	..	...	51.0	115.2	68.8	101.3	16
17	Bronze (Cu-Zn)	Rolled	6	6	54,000	50,200	54	57.2	90	..	10	...	...	..	...	..	...	90.5	134.9	89.4	122.8	17
Class 2, Aluminum Bronze																						
24	Bronze (Cu-Al)	Cast	1	1	90,000	45,000	15	80.4	80	..	..	...	...	Ni	Fe	..	10	2.7	15.3	1.4	14.5	24
22	Bronze (Cu-Al)	Forged	2	2	95,000	50,000	15	87.4	80	..	..	...	...	Ni	Fe	..	10	2.8	17.2	1.3	16.4	22
23	Bronze (Cu-Al)	Cast	3	3	43,900	....	79	−24.0	92	..	..	...	...	..	...	..	8	8.6	47.8	8.1	47.5	123
Class 3, Bronze																						
102	Bronze (Cu-Sn-Pb)	Cast	1	3	30,000	15,000	20	17.7	88	10	..	...	...	Ni	Fe	Pb	...	23.0	53.6	15.7	60.8	102
92	Bronze (Cu-Sn-Ni)	Cast	2	4	45,000	25,000	15	13.0	87.5	11	..	...	...	1.5	...	..	...	9.6	54.6	19.6	62.4	92
107	Bronze (Cu-Sn-Pb)	Cast	3	1	30,000	....	15	15.2	88	10	..	...	...	..	...	2	...	29.3	60.4	30.8	48.5	107
77	Bronze (Cu-Sn)	Cast	4	2	35,000	19,000	18	−9.1	90	10	..	...	...	..	...	..	...	22.8	67.8	20.4	59.9	77
78	Bronze (Cu-Sn-Pb)	Cast	5	5	32,000	15,000	18	44.5	85	10	..	...	...	..	...	5	...	51.9	95.6	52.7	76.1	78
101	Bronze (Cu-Sn-Pb)	Cast	6	6	22,000	15,000	12	1.2	80	6	..	...	...	..	...	14	...	76.5	107.5	73.0	106.5	101
Class 4, Silicon Bronze																						
93	Bronze (Cu-Si)	Cast	1	1	72,000	35,000	15	75.0	92–94	..	Zn	...	3–4	..	Fe	..	Al	11.1	42.6	12.0	40.4	93
91	Bronze (Cu-Si)	Cast	2	2	45,000	22,000	18	50.0	92–94	..	..	...	3–4	..	Fe	..	...	17.4	49.2	15.0	54.0	91
20	Bronze (Cu-Si-Mn)	Cast	3	3	45,000	22,000	20	36.5	94	..	..	1	5	..	...	..	...	15.7	52.4	20.5	54.5	20
151	Bronze (Cu-Si-Mn)	Rolled	4	4	90,000	60,000	12	94.0	96	..	..	1	3	..	...	.	...	20.2	56.1	20.2	56.1	151
9	Bronze (Cu-Si-Zn)	Rolled	5	5	91,000	51,000	..	89.0	95	..	2	...	3	..	...	..	...	27.4	65.9	18.7	59.5	9
159	Bronze (Cu-Si-Mn)	Drawn	6	7	68,000	....	50	49.2	96	..	..	1	3	..	...	..	...	18.7	66.8	20.6	65.7	159
15	Bronze (Cu-Si-Zn)	Rolled	7	6	77,000	53,000	64	87.2	96	..	1	...	3	..	...	..	...	27.7	71.6	22.0	62.7	15
Class 5, Manganese Bronze																						
23	Bronze (Cu-Zn-Al-Mn)	Forged	1	1	105,000	60,000	15	90.7	60–70	..	20–30	Mn	...	..	Fe	..	Al	3.5	19.2	4.5	19.9	23
21	Bronze (Cu-Zn-Al-Mn)	Cast	2	3	100,000	55,000	15	86.5	60 70	..	20–30	Mn	...	..	Fe	..	Al	5.9	23.2	4.3	22.0	21
89	Bronze (Cu-Zn-Al-Mn)	Cast	3	2	90,000	45,000	10	95.2	60–70	..	20 30	Mn	...	..	Fe	..	...	4.9	24.8	3.0	21.0	89
19	Bronze (Cu-Zn-Ni-Mn)	Cast	4	4	80,000	40,000	20	78.0	50 60	..	30–40	Mn	...	Ni	Fe	..	Al	11.1	38.1	10.6	37.2	19
76	Bronze (Cu-Zn-Al-Mn)	Cast	5	5	65,000	33,000	20	70.0	55–60	Sn	38–42	Mn	...	..	...	..	Al	15.8	51.0	18.2	53.0	76
115	Bronze (Cu-Zn-Fe-Mn)	Cast	6	6	76,000	....	35	65.3	58	Sn	40	Mn	...	..	1	..	Al	15.1	53.0	17.9	55.4	115
Class 6, Bronze																						
108	Bronze (Cu-Sn-Zn)	Cast	1	2	40,000	....	20	−4.0	88	9	3	...	...	..	...	..	...	22.9	48.6	21.6	65.0	108
88	Bronze (Cu-Sn-Zn)	Cast	2	1	35,000	17,000	20	0.7	88	10	2	...	...	..	...	..	...	20.3	65.8	18.9	57.4	88
84	Bronze (Cu-Sn-Zn-Pb)	Cast	3	3	27,000	12,000	16	−34.8	85	5	5	...	...	..	...	5	...	47.5	85.4	46.2	75.0	84
100	Bronze (Cu-Sn-Zn-Pb)	Cast	4	4	32,000	15,000	30	−12.3	85	6	4	...	...	..	...	5	...	41.4	90.4	39.3	86.1	100
Class 7, Nickel Copper																						
143	Nickel (Cu-Fe-Si)	Cast	1	1	100,000	90,000	2	109	32–33	..	..	...	4	62–63	2	..	...	4.8	20.0	3.3	21.4	143
142	Nickel (Cu-Fe-Al)	Drawn	2	2	150,000	116,000	20	106	30	..	.	Mn	Si	64	1	..	3–4	5.5	23.9	4.9	24.7	142
141	Nickel (Cu-Fe-Mn)	Drawn	3	3	85,000	60,000	30	75.4	29	..	..	1	...	68	1	..	...	14.6	53.3	12.2	53.2	141
171	Nickel (Cu-Mn)	Rolled	4	4	67,000	33,000	45	56.7	54	..	..	2	...	44	1	..	...	36.4	78.9	34.1	74.6	171
156	Nickel (Cu)	Rolled	5	5	55,000	18,000	37	66.7	70	..	..	...	...	30	...	..	...	50.4	86.2	50.4	87.6	156

TABLE 1 (Continued)

(FERROUS)

Serial no.	Material	Form	Scale 1: Fresh water	Scale 1: Sea water	Physical properties: Tensile strength, lb per sq in.	Physical properties: Yield strength, lb per sq in.	Physical properties: Elongation, per cent	Physical properties: Hardness Rockwell B	Chemical analysis, per cent: Carbon	Silicon	Copper	Molybdenum	Sulphur	Phosphorus	Manganese	Chromium	Nickel	Weight loss at 25 C, mg: Fresh water First 30 min	Fresh water Last 60 min	Sea water First 30 min	Sea water Last 60 min	Serial no.
Class 10, Iron																						
98	Iron	Cast	1	3	45,000	....	..	89.7	3.1	2.3	..	..	0.12	0.07	0.75	...	...	19.7	50.1	27.2	80.9	98
112	Iron	Cast	2	2	35,000	....	..	86.2	3.5	1.1	..	..	0.10	0.18	0.56	...	...	19.5	57.1	25.1	74.2	112
82	Iron	Cast	3	7	25,000	....	..	85.2	3.4	1.3	..	..	0.08	0.25	0.75	...	...	37.9	69.8	73.9	115.3	82
113	Iron	Cast	4	6	26,000	....	..	82.4	3.5	1.6	..	..	0.11	0.20	0.56	...	...	46.9	75.6	48.0	100.3	113
99	Iron	Cast	5	1	27,000	....	..	80.5	3.3	1.7	..	..	0.12	0.12	0.78	...	...	46.5	76.5	41.4	73.6	99
105	Iron	Cast	6	4	32,000	....	..	78.5	3.5	1.3	..	..	..	..	0.62	...	...	45.6	85.7	57.6	95.4	105
106	Iron	Cast	7	5	24,000	....	..	75.7	3.4	2.3	..	..	..	..	0.59	...	...	67.8	89.7	75.8	100.2	106
Class 11, Alloy Iron																						
163	Iron (Cu-Ni-Cr-Si)	Cast	1	1	25,000	....	..	82.9	3.0	1.9	6.0	..	..	..	..	4.0	14.4	28.7	41.6	28.6	51.4	163
103	Iron (Mn-Ni-Si)	Cast	2	4	47,000	....	..	100.0	2.7	1.8	..	..	..	..	1.0	...	1.9	10.9	43.0	29.4	65.1	103
114	Iron (Mn-Si)	Cast	3	2	48,000	....	..	98.3	3.0	2.5	0.42	..	0.09	0.10	0.92	...	0.74	13.1	46.1	15.7	59.5	114
166	Iron (Ni-Si)	Cast	4	6	30,000	....	..	105.5	2.9	1.4	..	..	..	..	..	...	4.8	19.5	50.9	39.9	88.7	166
104	Iron (Mo)	Cast	5	3	42,000	....	..	89.5	3.3	1.3	..	0.40	..	..	0.51	...	...	20.3	54.1	28.4	63.9	104
144	Iron (Cu-Ni-Cr-Si)	Cast	6	5	20,000	....	..	67.5	2.9	1.7	6.0	..	..	..	..	2.7	14.1	46.9	62.5	53.7	68.3	144
80	Iron (Ni-Si)	Cast	7	8	30,000	....	..	102.3	3.7	2.0	..	..	0.06	0.25	0.7	0.3	2.5	33.3	66.5	65.1	102.1	80
79	Iron (Mn-Cu-Ni-Cr)	Cast	8	7	20,000	....	..	32.5	3.0	1–2	6.0	..	0.10	0.04	1.0	1–3	12–15	72.0	85.3	70.3	95.3	79
Class 12, Steel																						
116	Steel	Rolled	1	1	84,000	41,000	28	97.8	0.35	..	..	..	..	0.45	0.67	...	...	4.0	34.2	8.5	39.6	116
97	Steel	Rolled	2	2	72,000	46,000	33	68.9	0.25	0.24	..	..	0.03	0.03	0.58	...	...	11.7	63.2	19.0	72.1	97
127	Steel	Rolled	3	3	66,000	31,000	34	60.8	0.27	..	..	..	0.40	0.45	0.48	...	...	19.7	68.3	20.7	77.8	127
83	Steel	Rolled	4	4	61,000	39,000	32	54.7	0.20	..	..	..	0.03	0.02	0.50	...	...	16.3	78.2	28.7	82.4	83
Class 13, Cast Steel																						
119	Steel	Cast	1	1	93,000	57,000	25	86.5	0.37	0.31	..	..	0.04	0.04	1.10	...	...	7.3	44.8	9.6	53.6	119
94	Steel	Cast	2	2	72,000	44,000	30	73.5	0.33	0.35	..	..	0.02	0.02	0.75	...	0.15	11.7	57.8	17.8	57.4	94
81	Steel	Cast	3	3	72,000	43,000	24	65.5	0.34	0.33	..	..	0.03	0.03	0.75	...	...	17.6	63.7	18.6	70.2	81
118	Steel	Cast	4	4	68,000	36,000	30	61.9	0.26	0.32	..	..	0.04	0.04	0.60	...	...	22.9	72.9	28.2	80.9	118
Class 15, Alloy Steel																						
165	Steel (Ni-Cr)	Rolled	1	1	152,000	128,000	..	103.5	0.34	0.20	..	..	0.03	0.02	0.52	0.60	1.18	3.7	20.0	4.0	22.0	165
172	Steel (Ni-Cr)	....	2	2	150,000[a]	100,000[a]	10[a]	99.7	0.40	0.30	..	..	Low	Low	0.50	1.10	4.50	3.5	23.1	5.4	25.8	172
126	Steel (Mn-Cu)	....	3	3	80,000	62,000	31	83.0	0.26	0.24	0.28	..	0.02	0.02	1.44	...	...	7.5	42.9	9.9	53.8	126
124	Steel (Ni-Cr)	....	4	6	113,000	101,000	23	76.5	0.40	0.65	..	..	0.05	0.04	0.61	...	1.29	9.7	49.7	11.8	59.0	124
170	Steel (Ni)	....	5	4	65,000[a]	40,000[a]	30[a]	85.0	..	..	..	..	..	..	..	...	36.0	15.4	51.8	18.4	54.8	170
125	Steel (Mn-Cr)	....	6	5	80,000	62,000	34	82.4	0.09	0.90	0.41	..	0.02	0.15	0.28	1.17	...	13.1	53.6	14.9	56.5	125
167	Steel (Ni)	....	7	7	75,000	58,000	36	76.5	0.08	0.14	..	..	0.02	0.02	0.42	...	4.8	11.8	56.6	13.5	62.1	167
169	Steel (Ni)	....	8	8	75,000	50,000	26	74.0	0.19	..	..	..	0.02	0.02	0.60	...	2.2	13.4	61.3	14.9	64.0	169
Class 16, Chrome Steel																						
131	Steel (Cr)	Rolled	1	1	77,000	45,000	33	112.0	0.08	0.57	..	..	0.02	0.03	0.47	17.2	0.34	6.4	11.8	4.2	10.8	131
128	Steel (Cr)	Rolled	2	2	83,000[a]	60,000[a]	20[a]	109.0	0.06	0.21	..	..	0.01	0.03	1.10	11.3	...	2.5	13.4	5.3	15.6	128
27	Steel (Cr)	Rolled	3	4	144,000	78,000	12	106.5	0.09	0.38	..	..	0.02	0.02	0.43	12.2	0.32	3.7	20.6	3.0	23.0	27
111	Steel (Cr)	Cast	4	3	172,000	87,000	13.5	104.0	0.07	0.38	..	..	0.02	0.02	0.34	12.5	1.3	6.7	20.7	6.0	22.9	111
Class 17, Nickel-Chromium Steel																						
175	Steel (Cr-Ni)	Cast	1	1	85,000[a]	26,000[a]	65[a]	81.2	0.15	0.50	..	..	..	..	0.50	16–20	8–12	1.8	13.5	1.0	13.4	175
173	Steel (Cr-Ni)	Cast	2	2	75,000[a]	17,000[a]	65[a]	92.0	0.07	0.50	..	..	..	..	0.50	16–20	8–12	2.0	14.7	2.1	14.8	173
174	Steel (Cr-Ni)	Cast	3	4	90,000[a]	30,000[a]	65[a]	83.3	0.21	0.50	..	..	..	..	0.50	16–20	8–12	0.2	14.7	0.9	15.7	174
132	Steel (Cr-Ni)	Rolled	4	3	85,000[a]	35,000	50	77.5	0.07	0.37	..	..	0.14	0.19	0.48	18.4	8.7	1.9	16.1	3.0	15.3	132
137	Steel (Cr-Ni-Mo)	Cast	5	5	70,000[a]	32,000[a]	30[a]	81.7	0.05	0.51	..	..	..	..	0.81	24.6	11.5	2.0	17.0	1.0	16.0	137
168	Steel (Cr-Ni)	Cast	6	6	114,000	78,000	31	89.7	?	1.13	..	..	..	0.19	..	8.0	21.0	2.6	17.9	2.7	19.8	168
12	Steel (Cr-Ni)	Cast	7	..	98,000	50,000	40	...	0.29	0.96	..	..	..	..	0.62	28.0	10.7	7.6	38.9	..	..	12

[a] Minimum of values to be expected.

air content of the water to a constant value. The dummy was then removed, and the test specimen inserted after having been carefully weighed on a precision balance sensitive to 0.25 mg.

The apparatus was vibrated for 30 min, the test specimen removed, another specimen inserted, and the first specimen carefully dried and weighed to determine the quantity of material eroded by cavitation. This process was repeated three times securing accurate values of weight loss at the end of 30, 60, and 90 min. A few tests were made taking measurements at intervals of 5 or 10 min for the first half-hour to determine more accurately the behavior in this range (Fig. 6).

Upon completion of the 90-min test period, the specimen was photographed with an enlargement of approximately 6 diameters, and the Rockwell hardness (B scale) measured on the periphery of the specimen.

The air content of the water was measured frequently during the tests. It decreased in the fluid during the initial part of the vibratory period, and the equilibrium points, in fresh water about 1.16 per cent air content and in sea water at 1.00 per cent, were reached after approximately 30 min (Fig. 4). These values are somewhat below the corresponding fresh-water saturation value of 1.6 per cent at 25 C.

Calibrating specimens of brass made from the same piece of rolled bar were employed from time to time to make certain that characteristics of the apparatus did not change during the investigation. The atmospheric pressure was measured repeatedly, but as far as could be established, slight variations did not influence the results to any noticeable extent.

Sea Water Used in Vibratory Tests

Sea water used in the vibratory tests was taken from three locations in Cobscook Bay, Eastport, Me.

Salinity, density, and hydrogen-ion concentration (pH), were measured in Eastport by the concrete laboratory staff, and density and air content were measured at Massachusetts Institute of Technology as a check upon the condition of the water during the test.

A typical analysis of sea water from Cobscook Bay is as follows:

	Grams per liter
Sodium (Na)	9.95
Magnesium (Mg)	1.50
Calcium (Ca)	0.41
Chloride (Cl)	17.83
Sulphate (SO_4)	2.54
Bromine (Br)	0.06
Potassium (K)	0.33

Density averages 1.023, and hydrogen-ion concentration (pH), varies from 8.0 to 8.1, indicating a decidedly alkaline reaction. The water is free from contamination from sewage or industrial wastes, and very little fresh water flows into Cobscook Bay to dilute the sea water.

The general character of the sea water approaches that found in the open ocean. It is free from the acid reaction of the water in Boston Harbor, where the pH is about 6.0. The neutral point is 7.0.

Effect of Temperature on Cavitation

In various research investigations made previously, it was observed that some difference in performance and in cavitation damage occurred with variations in temperature. In the venturi apparatus, cooling or heating coils were used to maintain constant temperatures, but the great volume of water and the large quantity of energy dissipated in the venturi throat made this temperature control difficult. The time required for a given test was long, and it was not usually possible to investigate thoroughly the relation between cavitation damage and temperature with extreme accuracy.

In the preliminary group of vibratory tests made for the Eastport district, the fluid was maintained at a constant temperature of 20 C, and, later, another preliminary investigation, utilizing aluminum-alloy samples was made to study the effect of temperature upon weight loss. This investigation showed that the cavitation damage in a given time doubled when the temperature was raised from 0 to approximately 50 C. This same effect was found to hold true in the case of a concentrated saline solution having 20 per cent, by weight, of sodium chloride. Damage was greater in this solution than was the case with fresh water, but loss in weight still reached its maximum at about 50 C. As temperature was increased beyond this point, damage decreased until it approached zero at the boiling point.

The effect of temperature, therefore, had to be considered carefully in this investigation, and the program was arranged so that the vibratory tests were run at a constant temperature of 25 C representing approximately the average between conditions at 0 C and maximum damage at 50 C.

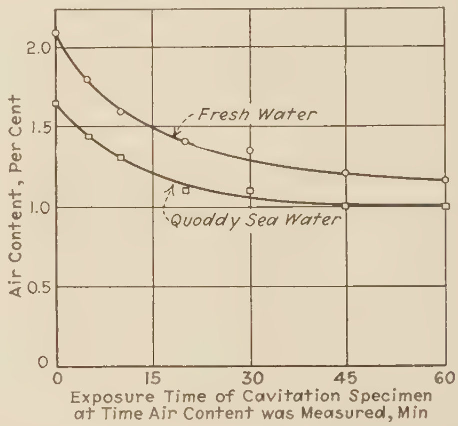


Fig. 4 Curve of Air Content With Respect to Time

(Air content = V_A/V_w, where V_A = volume of air dissolved in the water and V_w = volume of water tested. All volumes reduced to standard conditions of temperature and pressure, 0 C and 760 mm of mercury. Temperature of water during cavitation = 25 C. Corresponding air content of fresh water used in test = 1.6 per cent at saturation.)

The container holding the fluid, in which the specimen was vibrated, was kept in a constant-temperature bath, and variations from this constant temperature were held within very narrow limits. All tests were carried on for the standard time interval of 90 min, with intermediate weighings at 30 and 60 min. Following completion of the main group of vibratory tests, five different materials were selected for temperature studies; namely, brass, cast iron, and cold-rolled steel, which were tested in the original calibration studies; cast steel, serial 94; and cast iron, serial 105. The tests were made at 3, 14, 25, 38, and 50 C with both fresh and salt water. It was found that damage to specimens in fresh water reached its maximum at about 25 to 30 C for brass, whereas for the cast irons and the steels, the maximum condition appeared to be at or beyond 50 C. An insufficient number of tests was made to establish this relation definitely, but it was apparent that low-temperature conditions had a tendency to reduce the destructive effect and that there was a general tendency for this destructive effect to increase with temperature up to a certain point and then to decrease with still higher temperatures.

Corresponding tests were made in sea water for brass, cast iron, and cold-rolled steel, and in artificial sea water for cast steel, serial 94, and cast iron, serial 105. The same general behavior

was observed, but, in the case of both types of cast iron, damage at low temperatures was much greater in sea water than in fresh water.

The preliminary investigation combined with the later studies would indicate that change in cavitation damage with temperature is due to change in air content or vapor pressure or a combination of both. Colder water has the ability to dissolve more oxygen and other gases from the air, and these tend to go out of solution when subjected to the high-vacuum conditions that accompany cavitation, thus forming an air-cushion which reduces the force of the counterblow, and, hence, decreases cavitation erosion. As the temperature is increased, more and more of these dissolved gases are driven off, the return blow caused by collapse of the vacuum pocket is not cushioned, and the destructive effect is increased.

As the temperature is raised still further, the vapor pressure of the water or other fluid increases, and the vacuum pocket becomes filled with increasing volumes of water vapor. As the temperature approaches the boiling point, almost all of the force of the return blow is apparently absorbed by the cushioning action of the "steam," and, hence, the cavitation damage becomes negligible.

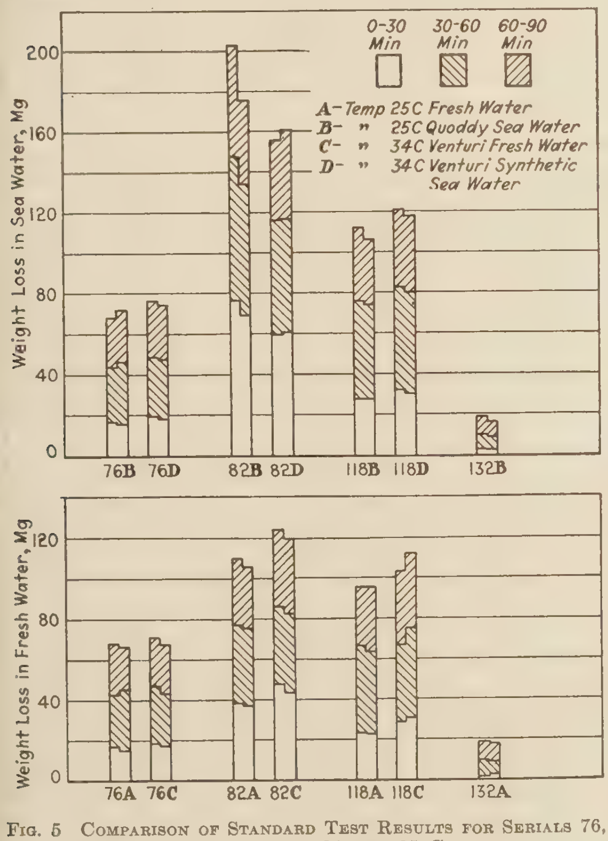


Fig. 5 Comparison of Standard Test Results for Serials 76, 82, and 118 at 34 and 25 C

For hydroelectric plants, the water temperature rarely exceeds 35 C and will usually be between 0 and 25 C. On the Passamaquoddy project, temperature of the water would rarely rise above 15 C, and, hence, selection of a standard temperature of 25 C represented conditions that approach maximum damage which would normally be found in such plants. The change in temperature from 25 C, which was the standard for the laboratory test, up to 34 C, which was the standard for the venturi testing, did not introduce any major discrepancy. In the case of serials 76, 82, and 118, a direct comparison (Fig. 5) has been shown of the destruction from 0 to 90 min in both fresh and sea water at these two different temperatures.

With pumping machinery, where water delivered to the suction side of the pump comes from a large reservoir or from the ocean, it is doubtful whether the temperature will exceed 35 C. Where pumping equipment is used in process industries or for handling boiler feedwater, these temperatures would naturally be greatly exceeded. The release of water vapor may reduce cavitation

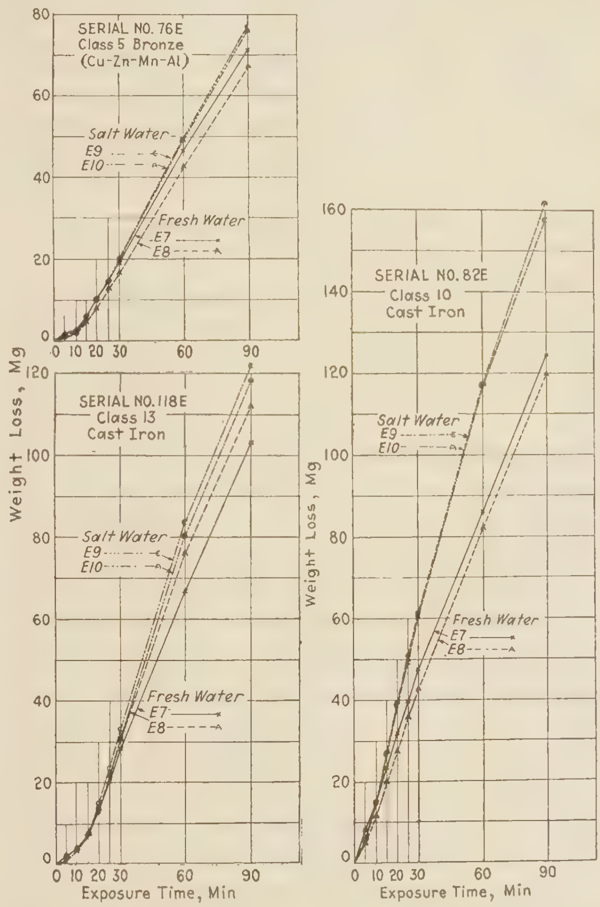


Fig. 6 Vibratory-Test Curves for Serials 76, 82, and 118 (These cavitation-erosion curves by the vibratory method were made simultaneously on the same materials tested by the venturi apparatus and maintained at the same temperature of 34 C. Standard vibratory tests at 25 C were also made and a comparison of the results is shown in Fig. 5.)

damage appreciably, but, at the same time, the high-vacuum conditions at suction could cause a change in pump characteristics which might impair its efficiency greatly, even though the blades were not being damaged by cavitation.

Effect of Pressure on Cavitation

It is important to note that all of these vibratory tests have been made at atmospheric pressure. If the pressure were increased, the entire phenomenon might be changed, as water would be held against the surface of the specimen, and, thus, the tendency toward formation of vacuum pockets would be reduced. It is a well-established fact that severe cavitation can be corrected by an increase in the back pressure on the turbine, or by an increase in suction pressure on a pump.

At the naval model basin located in the Washington, D. C., Navy Yard, marine propellers are tested under various conditions of flow and pressure. Cavitation can be eliminated almost entirely if absolute pressure of the water with respect to the propeller blade is increased sufficiently. The opposite effect is noted if pressure is decreased, as cavitation areas form and gradually reach sufficient proportions to change flow conditions past the blades and, thus, impair the effectiveness of the propellers. This same basic relation holds true in hydraulic turbines and pumps, and it also applies in the venturi type of cavitation-testing apparatus, since a sufficiently high back pressure will hold the flow against the walls of the tube and prevent the formation of the vacuum pockets.

Detailed research on the effect of varying pressures in the vibratory apparatus has not yet been undertaken, but it is probable that cavitation damage will be reduced if a substantially higher pressure than atmospheric is exerted on the surface of the liquid. It was noted that the very small variation in atmospheric pressures experienced during the Eastport District tests made no measurable difference in damage due to caviation.

Effect of Variations in Fluids Upon Cavitation

In preliminary investigations undertaken by Massachusetts Institute of Technology, prior to the contract with the Eastport District Engineer Office, tests were made with aluminum-alloy samples in the vibratory apparatus, using fresh water, a 20 per cent solution of sodium chloride, and a solution of methyl alcohol. The denser liquid caused greater damage, and the volatile liquid, such as alcohol, caused relatively small damage due probably to high vapor pressure and cushioning of the cavitation blow by a pocket of vapor. Previous discussion in regard to variation of cavitation damage with temperature is further amplified by tests using different fluids.

With sea water, cavitation damage has usually been slightly greater than with fresh water, particularly with soft or porous materials, and is very pronounced with cast iron. This greater proportional damage with cast iron and some cast steels is undoubtedly due to a combination of the changes in density, air content, and vapor pressure but must also be influenced by the highly corrosive action of sea water upon ferrous materials.

Measures of Pitting

There is no established measure or unit of comparison for cavitation damage, although many attempts have been made to set up some means of evaluation. With hydraulic-turbine installations studied by the hydraulic power committee of the National Electric Light Association, cavitation damage[6] was grouped roughly into three classes: The first class, designated as "no pitting," included wheels showing little or no pitting in 10 years' service, with a probable life of 20 years without repairs. The second class, "moderate pitting," included those wheels whose life could be extended to 20 years by minor repairs. The third class, "excessive pitting," comprised wheels requiring replacement in less than 10 years. This method was open to differences of opinion between manufacturers and purchasers of equipment, and cases were found where pitting, which covered relatively small areas and did not affect the strength of the runner, was designated as "excessive pitting," calling for replacement within 10 years. These designations were finally dropped from use.

The advent of electric welding permitted repair of cast-steel runners in place without the necessity of dismantling any equipment. In the case of cast-iron runners, some repair work was done in place, but this involved expensive work, owing to the difficulty of welding material onto cast iron. Some bronze runners were repaired in place, but, with both cast iron and bronze, it was frequently found simpler to replace the runner and carry on the repair work at a convenient location in the power house. This avoided a long shutdown of the unit and permitted a better final result.

The quantity of welding rod used in repairs by welding offered, for the first time, a means whereby cavitation damage could be measured. The "pounds of welding rod per runner" became the first unit of measurement. In some turbine contracts, a guarantee clause was set up which used some arbitrary value of weight of welded metal required for repairs to determine the liability of the manufacturer in correcting cases of pitting. This method also proved unpopular and is now rarely used.

Both of these early attempts to set up a measure of cavitation erosion were based upon actual damage occurring during operation and required a long time. They did not give assurance against pitting; moreover, the operating conditions such as draft head, percentage of load, and other vital characteristics did not remain the same on all units or at all seasons.

Better understanding of the nature of cavitation and growing use of tests of model turbines under varying conditions of draft head have permitted the predetermination of the effect of cavitation and made it possible to avoid much of the trouble previously experienced. With the advent of the venturi-type cavitation-testing apparatus, it was possible to measure for the first time, under standardized conditions, the actual weight of metal removed by the destructive action of cavitation. This varied with the size of specimen, the area affected, and with the size and the local conditions existing in the particular apparatus in which the tests were made. The weight loss which is determined from such tests is not always the absolute measure of damage, as plastic deformation may occur without a corresponding loss of material.

Preliminary Scale of Relative Resistance to Erosion

In outlining the program with the Massachusetts Institute of Technology, it was decided to set up a scale of relative resistance which would be based upon the weight loss of standard specimens at standard temperatures during accurately measured time intervals. Materials which lost the least weight would be placed at the top of the scale, and those which lost the greatest weight would be placed at the bottom.

One basis of comparison employed the weight loss of one particular material as a standard. Weight loss on this material was to be determined very carefully and considered equal to unity in the resistance scale. Serial 82, a common variety of cast iron with a carbon content of 3.3 per cent and small percentages of manganese and silicon, was selected. For the first 30 min, this material lost 37.9 mg, and this was made equal to unity in the relative scale for the period of 0 to 30 min. Measured weight loss for other materials in the same time was then divided into this standard weight loss, and the quotient represented the value of relative resistance. The highest value of relative resistance represented the most durable material, and the lowest value represented the material that suffers the most damage. The same method was used for periods of from 0 to 60 and 0 to 90 min, the standard weight losses being 75.2 mg for the former and 107.7 mg for the latter.

This relative-resistance scale had the disadvantage of being an arbitrary ratio, based upon some particular material. While the average weight loss of seven specimens of cast iron, class 10, was 37.1 mg and while this corresponded very closely to the weight loss of the particular type of material selected, it nevertheless was an artificial standard and one that could not be reproduced with ease.

[6] "Pitting of Hydraulic Turbine Runners," National Electric Light Association Publication No. 256–18, April, 1926.

Final Relative Resistance Scales

Another and more satisfactory method was developed as a result of study of the various test curves. It was noted that a number of materials, particularly those having high strength and dense grain structure, would not lose weight at a uniform rate throughout the entire 90-min period but would have a time lag and, for the first 30 min, would have a weight loss somewhat less than that experienced during each of the two subsequent 30-min intervals. This was found with practically all high-strength and forged materials, whereas, with low-strength or cast materials, the rate of weight loss was practically uniform from 0 to 90 min and, during the first 30 min, indicated no sign of the lag that was present with other types.

On three selected materials, serials 76, 82, and 118, behavior in the initial 30-min period was investigated after each 5 min of exposure from 0 to 30 min and for each 30 min thereafter. On the cast material, serial 82, cavitation damage progressed at a relatively uniform rate from the very beginning of exposure in the vibratory apparatus. Bronze, serial 76, indicated little or no damage in the first 5 min, but, at the end of 15 min, a relatively uniform rate had been established which continued for the remaining exposure time. In the case of steel, serial 118, this uniform rate was not reached until about 20 min. Fig. 6 shows the results of this study.

Inspection of all individual test results indicated that, at the end of the first 30 min, cavitation erosion was taking place at a relatively uniform rate, but, during the first 30 min, wide variations were present. This analysis led to the division of the vibratory-test work into two parts, namely, the period from 0 to 30 min giving an indication of the initial resistance to cavitation and, second, the period from 30 to 90 min representing the relative resistance to uniform continued cavitation erosion. By segregating results into these two groups, skin effect could be considered, and higher initial resistance to cavitation indicated from the data already obtained. Variation due to finish or heat-treatment may have a measurable effect upon initial breaking down of the surface, but, after the surface was once broken through, destruction would progress fairly uniformly and make its way at a steady rate through material of relatively constant density.

The nature of cavitation indicates the desirability of distinguishing between these two actions and, based upon the vibratory tests, two separate scales of relative resistance have been set up.

Scale 1. Relative resistance to erosion is the index of the uniform erosive or pitting action, which takes place after the ultimate strength or fatigue limit has been reached.

Scale 2. Initial resistance to erosion is an index of the plastic-deformation period prior to reaching the fatigue limit of the metal.

These were both based upon actual weight loss in milligrams rather than upon a ratio established with respect to some arbitrarily selected material. The unit of "milligrams per hour" could be used as all specimens in the vibratory series were of the same dimensions.

Accuracy

Reliability of the results depends upon four main factors

(1) Constant frequency of the vibrator
(2) Accuracy in the determination of weight losses
(3) Uniformity of the material
(4) Uniformity of composition and temperature of the fluid

Investigation showed that the vibratory apparatus was kept at a constant frequency of 6700 cycles per sec by using the natural frequency of the nickel tube. The amplitude of 0.09 mm was kept uniform by regulating the power input to the oscillator. It is believed that the vibration frequency and amplitude were maintained within 2 per cent above or below the normal value. Weight loss, particularly at the end of the 90-min period, was sufficient to insure accuracy within 2 per cent, and the materials tested seemed to be unusually uniform with very few exceptions. Where a major discrepancy occurred between results of two specimens, a third was usually tested, and the average used, unless some condition during test indicated that results from a particular specimen should be discarded.

Air content, temperature, and composition of the fresh and salt water were checked repeatedly, and the variations were found to be negligible.

Check tests indicated that an individual specimen might be shifted two places on the relative scales, but the average of tests of two specimens would probably prevent a shift of more than one place. The position of the average of one classification would be unchanged.

Index of Fatigue Limit

The time at which a uniform rate of weight loss is reached in the vibratory apparatus may indicate the transition point between conditions of plastic flow or of work hardening and the condition of pitting which occurs after the fatigue limit has been passed. It may be noted in Fig. 6 that the change in the rate of weight loss is not usually abrupt but is a gradual increase which occurs over a period of 10 to 30 min. Beyond this time, however, damage takes place at a relatively uniform rate for some appreciable time.

It is possible that behavior during the first half-hour of exposure in the vibratory apparatus may prove to be a convenient method by which the approximate fatigue point may be determined. Frequency of oscillation in the vibratory apparatus equals about 400,000 applications of stress per minute, and, for 30 min of exposure, this total reaches the enormous figure of 12,000,000. In a fatigue-testing apparatus operating at 1000 rpm, it would require about 200 hr or slightly over 8 days of continuous operation to equal this number of stress applications. Therefore, it may be possible to use the vibratory method of cavitation testing as an index of the approximate number of applications of stress required to break down the structure of any given material, and, hence, to show a relative fatigue value, to be used as a guide in predicting behavior of the metal in the regular fatigue-testing apparatus.

Appearance of Specimens

Each of the vibratory specimens had certain characteristics in common. The pitted area covered a diameter of $^3/_8$ to $^7/_{16}$ in. surrounded by an annular area which was unaffected by cavitation. High frequency of vibration probably concentrated cavitation in the smaller area, and the portion near the outside of the specimen had the action relieved by the surrounding liquid. The time interval between pressure and vacuum was evidently too short for the relief to travel more than $^1/_8$ in. With high-strength materials, the area was smaller in diameter and had the appearance of being sandblasted. With softer or weaker materials, the area affected was larger and the depth of pitting was greatest near the center. With the softest or weakest materials, such as plain cast iron, the depth of pitting was more uniform over the area but where nonuniform material was encountered, the pitting was deepest at the softer portions, and, in certain cases, narrow fissures extended into the outer area.

Photographs, magnified several times, are included of representative specimens in each class of material. The complete set of venturi specimens is shown for comparison. It will be noted that the deep-pitting stage had not yet been reached at the end of the test, usually not less than 50 hr. On the cast-iron specimens,

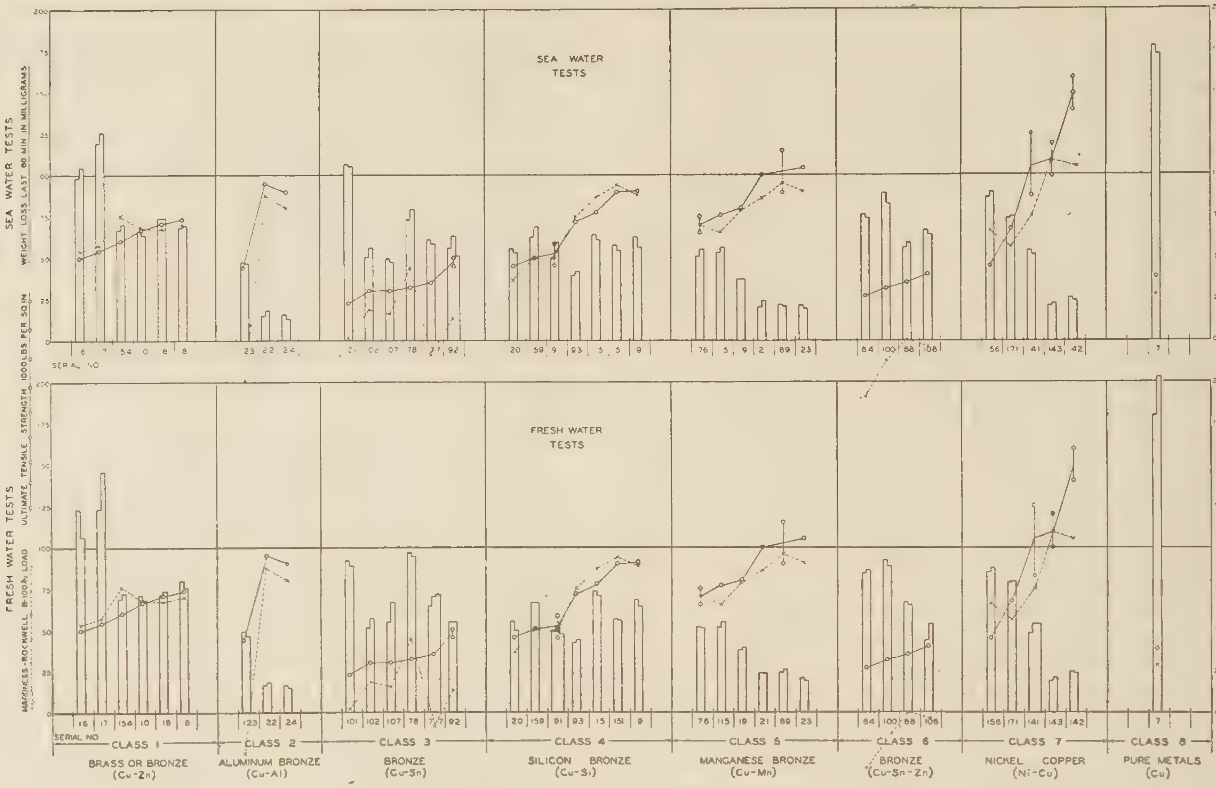


Fig. 7 Result of Tests of Nonferrous Materials

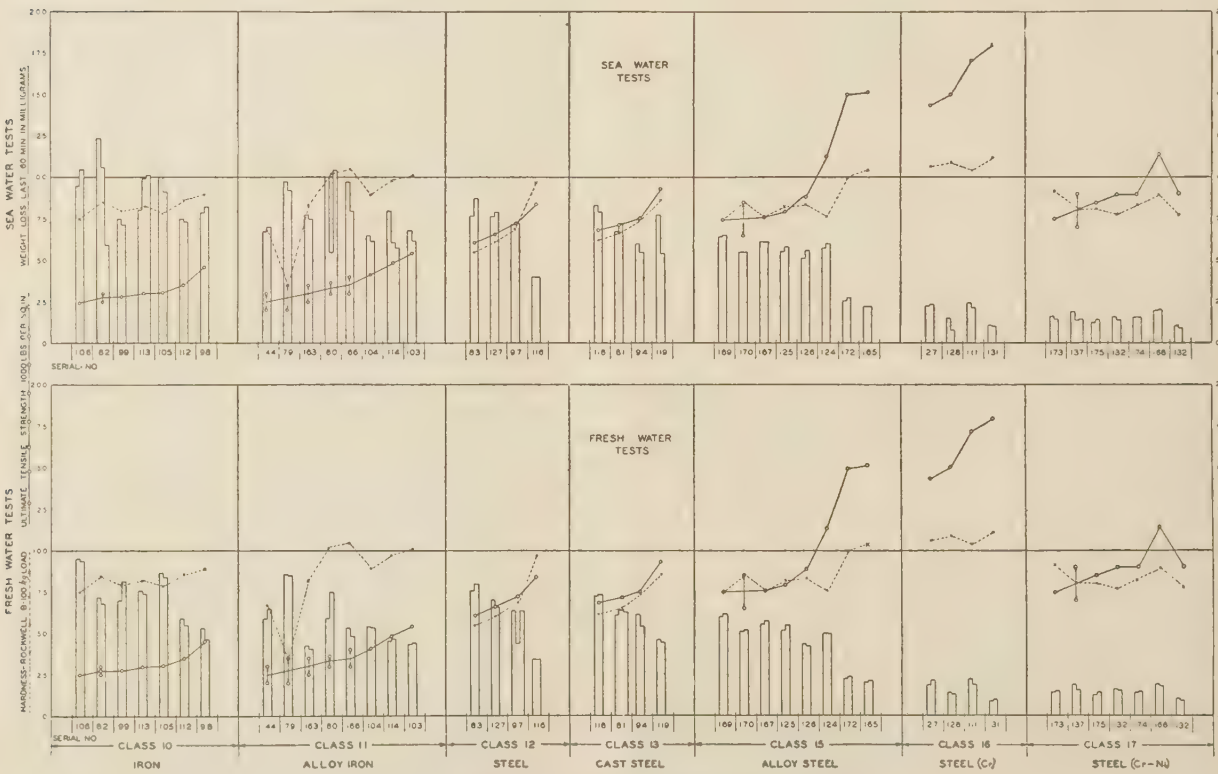


Fig. 8 Result of Tests of Ferrous Materials

evidence of corrosion on the venturi specimens was present with less pitting than is found on the vibratory specimens with an exposure period of only 90 min.

Results

The graphical representation of the results comprises two graphs, Fig. 7 for nonferrous and Fig. 8 for ferrous materials. Weight loss in the interval from 30 to 90 min has been plotted vertically for each specimen. Two or three specimens of each type of material are shown as a block with the upper end indicating small differences in weight loss for each specimen tested.

Results in fresh water are shown at the bottom of the sheet, and, immediately above them, are results of the tests in sea water. Ultimate tensile strength and hardness, based on the Rockwell B scale, have also been plotted for reference, and the different materials have been arranged from left to right in order of their tensile strength. Thus, the first material in any classification represents the type having lowest ultimate strength, whereas the material on the right is the one having highest ultimate strength.

Another method of illustrating relative resistance is by tabulating the materials according to weight losses for the two periods selected. Scale 1 for the 60 min following the initial half-hour period of exposure and scale 2 (the initial resistance to cavitation erosion), are shown in Figs. 9 and 10, respectively, the unit of milligrams per hour being used throughout.

Tables 2 and 3 give the *average* weight losses of each class for the uniform and initial scales, respectively, and form consolidated "relative scales" for nonferrous materials. Tables 4 and 5 give the same data for ferrous materials.

Performance by Classes

Each material, with individual compositions and distinguishing features, has been listed by classes in Table 1. Graphical summaries are inadequate to cover outstanding characteristics encountered in the tests. The behavior of each class of material will be described in detail, with the individual samples cited where their performance was unusual or distinct from others in the group.

Nonferrous Materials (Fig. 7)

Class 1, Brass or Bronze (Cu-Zn). This group comprises ordinary brass or bronze. Softer materials, having 85 to 90 per cent of copper and the remainder zinc, are lower in tensile strength. Remaining specimens have a composition of 60 per cent of copper and 40 per cent of zinc. High-copper alloys show much greater damage from cavitation than does 60–40 brass. There is little or no change in the performance in fresh water, as compared with sea water, and results of the four different 60–40 specimens show remarkably close agreement, having a cavitation damage between 70 and 75 mg per hr. These materials rank at the bottom of the average relative resistance scales for both cavitation erosion and for initial resistance to cavitation in either fresh or salt water.

Class 2, Aluminum Bronze (Cu-Al). In this group of aluminum bronzes, only three specimens were available for cavitation testing. Serial 123, having 92 per cent of copper and 8 per cent of aluminum has a lower ultimate strength than the ordinary brasses or bronzes in class 1 but shows appreciably less cavitation damage, being on the order of 50 mg per hr. The two high-strength bronzes, averaging 100,000 lb per sq in. ultimate, show about 15 mg per hr, and compare favorably with the best of the high-strength alloy steels in so far as erosion is concerned. This material shows little or no change in cavitation damage in fresh water, as compared with sea water, and stands at the top of the

TABLE 2 RELATIVE RESISTANCE TO CAVITATION EROSION FOR NONFERROUS MATERIALS, SCALE 1

Relative order	Class	Materials	Weight loss for last 60 min exposure, mg per hr Average	Maximum	Minimum
		In fresh water			
1	2	Bronze (Cu-Al)	26.8	47.8	15.4
2	5	Bronze (Cu-Mn)	36.0	53.0	19.2
3	7	Nickel-copper (Ni-Cu)	52.5	86.2	20.1
4	4	Bronze (Cu-Si)	60.3	71.6	49.2
5	6	Bronze (Cu-Sn-Zn)	72.6	90.4	48.6
6	3	Bronze (Cu-Sn)	73.3	107.6	53.6
7	1	Brass or bronze (Cu-Zn)	90.1	134.7	69.5
		In salt water			
1	2	Bronze (Cu-Al)	26.2	47.5	14.5
2	5	Bronze (Cu-Mn)	35.6	55.4	19.9
3	7	Nickel-copper (Ni-Cu)	52.3	87.6	21.4
4	4	Bronze (Cu-Si)	58.8	65.7	54.0
5	3	Bronze (Cu-Sn)	69.2	106.5	48.5
6	6	Bronze (Cu-Sn-Zn)	70.9	86.1	57.4
7	1	Brass or bronze (Cu-Zn)	83.5	122.8	65.2

TABLE 3 INITIAL RESISTANCE TO CAVITATION EROSION FOR NONFERROUS MATERIALS, SCALE 2

Relative order	Class	Materials	Weight loss for first 30 min exposure, mg per hr Average	Maximum	Minimum
		In fresh water			
1	2	Bronze (Cu-Al)	9.6	17.4	5.6
2	5	Bronze (Cu-Mn)	19.2	31.8	7.0
3	4	Bronze (Cu-Si)	41.8	55.4	30.8
4	7	Nickel-copper (Ni-Cu)	44.6	100.8	9.6
5	6	Bronze (Cu-Sn-Zn)	69.6	95.0	40.6
6	3	Bronze (Cu-Sn)	71.2	153.0	19.4
7	1	Brass or bronze (Cu-Zn)	87.6	181.0	50.6
		In salt water			
1	2	Bronze (Cu-Al)	7.2	16.2	2.6
2	5	Bronze (Cu-Mn)	20.2	36.4	6.0
3	4	Bronze (Cu-Si)	39.0	45.8	30.2
4	7	Nickel-copper (Ni-Cu)	42.0	100.8	6.6
5	6	Bronze (Cu-Sn-Zn)	63.0	92.4	37.8
6	3	Bronze (Cu-Sn)	70.6	145.8	31.4
7	1	Brass or bronze (Cu-Zn)	86.0	178.8	45.0

TABLE 4 RELATIVE RESISTANCE TO CAVITATION EROSION FOR FERROUS MATERIALS, SCALE 1

Relative order	Class	Materials	Weight loss for last 60 min exposure, mg per hr Average	Maximum	Minimum
		In fresh water			
1	17	Steel (Cr-Ni)	15.6	17.9	13.5
2	16	Steel (Cr)	16.6	20.7	11.8
3	15	Alloy steel	43.7	61.4	20.1
4	11	Alloy iron	56.2	85.3	41.6
5	13	Cast steel	59.8	72.8	44.8
6	12	Steel	61.0	78.2	34.3
7	10	Iron	70.4	94.8	50.1
		In salt water			
1	17	Steel (Cr-Ni)	15.5	17.9	13.2
2	16	Steel (Cr)	18.1	23.1	10.8
3	15	Alloy steel	48.9	64.7	22.0
4	13	Cast steel	65.6	80.9	53.6
5	12	Steel	67.9	82.7	39.8
6	11	Alloy iron	74.3	102.2	51.4
7	10	Iron	87.0	115.3	56.5

TABLE 5 INITIAL RESISTANCE TO CAVITATION EROSION FOR FERROUS MATERIALS, SCALE 2

Relative order	Class	Materials	Weight loss for first 30 min exposure, mg per hr Average	Maximum	Minimum
		In fresh water			
1	17	Steel (Cr-Ni)	3.6	5.2	0.4
2	16	Steel (Cr)	9.8	13.4	5.2
3	15	Alloy steel	18.6	30.8	7.0
4	12	Steel	26.0	39.4	8.0
5	13	Cast steel	30.0	45.8	15.8
6	11	Alloy iron	57.6	115.8	21.8
7	10	Iron	74.2	135.4	26.2
		In salt water			
1	17	Steel (Cr-Ni)	3.6	6.0	1.8
2	16	Steel (Cr)	9.4	12.0	6.0
3	15	Alloy steel	22.4	37.8	8.0
4	13	Cast steel	37.2	56.4	19.2
5	12	Steel	38.6	57.6	17.0
6	11	Alloy iron	81.8	133.4	31.4
7	10	Iron	91.0	151.6	30.0

scales for the nonferrous group for both cavitation erosion and initial resistance to cavitation.

Class 3, Bronze (Cu-Sn). This classification covers the ordinary copper and tin alloys, varying from 78 to 90 per cent of copper and the remainder tin, except in the case of serial 107,

SCALE I

WEIGHT LOSS IN MILLIGRAMS PER HOUR	SCALE OF RELATIVE RESISTANCE TO CAVITATION EROSION							
	NON FERROUS MATERIALS				FERROUS MATERIALS			
	FRESH WATER		SALT WATER		FRESH WATER		SALT WATER	
	SERIAL	MATERIAL	SERIAL	MATERIAL	SERIAL	MATERIAL	SERIAL	MATERIAL
5	—	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—
15	—	—	24	BRONZE (2) Cu-Al	131 120 175 173 174	STEEL (16) Cr STEEL (16) Cr STEEL (17) Cr-Ni STEEL (17) Cr-Ni STEEL (17) Cr-Ni	131 175 173	STEEL (16) Cr STEEL (17) Cr-Ni STEEL (17) Cr-Ni
20	24 22 23	BRONZE (2) Cu-Al BRONZE (2) Cu-Al BRONZE (5) Cu-Mn	22 23	BRONZE (2) Cu-Al BRONZE (5) Cu-Mn	132 137 168	STEEL (17) Cr-Ni STEEL (17) Cr-Ni STEEL (17) Cr-Ni	132 120 174 137 168	STEEL (17) Cr-Ni STEEL (16) Cr STEEL (17) Cr-Ni STEEL (17) Cr-Ni STEEL (17) Cr-Ni
25	143 21 142 89	NICKEL COPPER (7) Ni-Cu BRONZE (5) Cu-Mn NICKEL COPPER (7) Ni-Cu BRONZE (5) Cu-Mn	89 143 21 142	BRONZE (5) Cu-Mn NICKEL COPPER (7) Ni-Cu BRONZE (5) Cu-Mn NICKEL COPPER (7) Ni-Cu	165 27 111 172	STEEL (15) Ni-Cr STEEL (16) Cr STEEL (16) Cr STEEL (15) Ni-Cr	165 111 27	STEEL (15) Ni-Cr STEEL (16) Cr STEEL (16) Cr
30	—	—	—	—	—	—	172	STEEL (15) Ni-Cr
35	—	—	—	—	116	STEEL (12) Rolled	—	—
40	19	BRONZE (5) Cu-Mn	19	BRONZE (5) Cu-Mn	—	—	116	STEEL (12) Rolled
45	93	BRONZE (4) Cu-Si	93	BRONZE (4) Cu-Si	163 103 126 119	IRON (11) Ni-Cu (Cast) IRON (11) Ni (Cast) STEEL (15) Mn-Cu STEEL (13) Cast	—	—
50	123 108 91	BRONZE (2) Cu-Al BRONZE (6) Cu-Sn-Zn BRONZE (4) Cu-Si	123 107	BRONZE (2) Cu-Al BRONZE (3) Cu-Sn	114 124	IRON (11) Si (Cast) STEEL (15) Ni-Cr	—	—
55	76 20 115 141 102 92	BRONZE (5) Cu-Mn BRONZE (4) Cu-Si BRONZE (5) Cu-Mn NICKEL COPPER (7) Ni-Cu BRONZE (3) Cu-Sn BRONZE (3) Cu-Sn	76 141 91 20	BRONZE (5) Cu-Mn NICKEL COPPER (7) Ni-Cu BRONZE (4) Cu-Si BRONZE (4) Cu-Si	98 166 170 125 104	IRON (10) Cast IRON (11) Ni (Cast) STEEL (15) Ni STEEL (15) Cr-Si IRON (11) Mo (Cast)	163 119 126 170	IRON (11) Ni-Cu (Cast) STEEL (13) Cast STEEL (15) Mn-Cu STEEL (15) Ni
60	151	BRONZE (4) Cu-Si	115 151 88 9	BRONZE (5) Cu-Mn BRONZE (4) Cu-Si BRONZE (6) Cu-Sn-Zn BRONZE (4) Cu-Si	167 112 94	STEEL (15) Ni IRON (10) Cast STEEL (13) Cast	125 94 124 114	STEEL (15) Cr-Si STEEL (13) Cast STEEL (15) Ni-Cr IRON (11) Si (Cast)
65	107	BRONZE (3) Cu-Sn	77 102 92 15	BRONZE (3) Cu-Sn BRONZE (3) Cu-Sn BRONZE (3) Cu-Sn BRONZE (4) Cu-Si	169 144 97	STEEL (15) Ni IRON (11) Ni-Cu (Cast) STEEL (12) Rolled	167 104 169	STEEL (15) Ni IRON (11) Mo (Cast) STEEL (15) Ni
70	9 88 159 77 10	BRONZE (4) Cu-Si BRONZE (6) Cu-Sn-Zn BRONZE (4) Cu-Si BRONZE (3) Cu-Sn BRONZE (1) Cu-Zn	108 10 159 154 8	BRONZE (6) Cu-Sn-Zn BRONZE (1) Cu-Zn BRONZE (4) Cu-Si BRONZE (1) Cu-Zn BRASS (1) Cu-Zn	81 80 127 82	STEEL (13) Cast IRON (11) Ni (Cast) STEEL (12) Rolled IRON (10) Cast	103 144	IRON (11) Ni (Cast) IRON (11) Ni Cu (Cast)
75	154 15 18	BRONZE (1) Cu-Zn BRONZE (4) Cu-Si BRONZE (1) Cu-Zn	18 171	BRONZE (1) Cu-Zn NICKEL COPPER (7) Ni-Cu	118	STEEL (13) Cast	81 97 99 112	STEEL (13) Cast STEEL (12) Rolled IRON (10) Cast IRON (10) Cast
80	8 171	BRASS (1) Cu-Zn NICKEL COPPER (7) Ni-Cu	84 78	BRONZE (6) Cu-Sn-Zn BRONZE (3) Cu-Sn	113 99 83	IRON (10) Cast IRON (10) Cast STEEL (12) Rolled	127	STEEL (12) Rolled
85	—	—	—	—	—	—	98 118 83	IRON (10) Cast STEEL (13) Cast STEEL (12) Rolled
90	84 156	BRONZE (6) Cu-Sn-Zn NICKEL COPPER (7) Ni-Cu	100 156	BRONZE (6) Cu-Sn-Zn NICKEL COPPER (7) Ni-Cu	79 105	IRON (11) Ni-Cu (Cast) IRON (10) Cast	166 79	IRON (11) Ni (Cast) IRON (11) Ni-Cu (Cast)
100	100 78	BRONZE (6) Cu-Sn-Zn BRONZE (3) Cu-Sn	—	—	106	IRON (10) Cast	105	IRON (10) Cast
120	101 16	BRONZE (3) Cu-Sn BRASS (1) Cu-Zn	16 101	BRASS (1) Cu-Zn BRONZE (3) Cu-Sn	—	—	106 113 80 82	IRON (10) Cast IRON (10) Cast IRON (11) Ni (Cast) IRON (10) Cast
140	17	BRONZE (1) Cu-Zn	17	BRONZE (1) Cu-Zn	—	—	—	—
200	7	COPPER (8) Cu	7	COPPER (8) Cu	—	—	—	—

Fig. 9 Relative Resistance Scale 1 (Uniform Erosion)

(Relative resistance based on weight loss between 30 to 90 min measurement.)

where 2 per cent of lead is included, and serial 78, where 5 per cent of lead is included. As before, high copper content apparently reduces ultimate strength and also reduces materially resistance to erosion. In the case of serial 101, which is an 86–14 alloy, the damage in fresh water is about 85 mg per hr, but, in sea water, this increases to 105 mg per hr. In contrast to this, the remaining materials in this classification either show no change between fresh and sea water or else indicate a reduction in cavitation damage, such as serial 78 for example, which decreases from 95 mg per hr in fresh water to 75 mg per hr in sea water. Some slight change is found in the performance of serial 77, which is a 90–10 alloy, the damage decreasing from 68 to about 60 mg per hr. In general, class 3 ranks sixth on the relative-resistance scales, but, due to less damage being suffered in salt water by all but serial 101, it is raised to fifth place on scale 1 for resistance to cavitation erosion for sea water. Its position remains sixth on scale 2 for initial resistance in either fresh or salt water.

Class 4, Silicon Bronze (Cu-Si). This group represents a wide range in chemical composition, but most samples have about 95 per cent of copper and from 2 to 5 per cent of silicon with certain other materials included in some cases. Average weight loss is about 50 mg per hr in either fresh or salt water but shows slightly less in sea water. It stands fourth on scale 1 for erosion in both fresh and salt water, but stands third on scale 2 for initial resistance, due to the greater skin effect than class 7. This material, together with class 5, is used widely in machinery and, in most cases, should prove satisfactory.

Class 5, Manganese Bronze (Cu-Mn). These materials have approximately the same chemical composition throughout but vary in ultimate tensile stress from 70,000 to 100,000 lb per sq in. Usual composition averages about 60 per cent of copper, about

SCALE II

WEIGHT LOSS IN MILLIGRAMS PER HOUR	INITIAL RESISTANCE TO CAVITATION EROSION							
	NON FERROUS MATERIALS				FERROUS MATERIALS			
	FRESH WATER		SALT WATER		FRESH WATER		SALT WATER	
	SERIAL	MATERIAL	SERIAL	MATERIAL	SERIAL	MATERIAL	SERIAL	MATERIAL
2	—	—	—	—	174	STEEL (17) Cr-Ni	174	STEEL (17) Cr-Ni
6	24 22	BRONZE (2) Cu-Al BRONZE (2) Cu-Al	22 24	BRONZE (2) Cu-Al BRONZE (2) Cu-Al	175 132 173 137 128 168	STEEL (17) Cr-Ni STEEL (17) Cr-Ni STEEL (17) Cr-Ni STEEL (17) Cr-Ni STEEL (16) Cr STEEL (17) Cr-Ni	137 175 173 168	STEEL (17) Cr-Ni STEEL (17) Cr-Ni STEEL (17) Cr-Ni STEEL (17) Cr-Ni
10	23 143 89	BRONZE (5) Cu-Mn NICKEL COPPER (7) Ni-Cu BRONZE (5) Cu-Mn	89 143 21 23 142	BRONZE (5) Cu-Mn NICKEL COPPER BRONZE (5) Cu-Mn BRONZE (5) Cu-Mn NICKEL COPPER (7) Ni-Cu	172 165 27 116	STEEL (15) Ni-Cr STEEL (15) Ni-Cr STEEL (16) Cr STEEL (12) Rolled	132 27 165 131	STEEL (17) Cr-Ni STEEL (16) Cr STEEL (15) Ni-Cr STEEL (16) Cr
20	142 21 123 92	NICKEL COPPER (7) Ni-Cu BRONZE (5) Cu-Mn BRONZE (2) Cu-Al BRONZE (3) Cu-Sn	123	BRONZE (2) Cu-Al	131 111 119 126 124	STEEL (16) Cr STEEL (16) Cr STEEL (13) Cast STEEL (15) Mn-Cr STEEL (15) Ni-Cr	128 172 111 116 119 126	STEEL (16) Cr STEEL (15) Ni-Cr STEEL (16) Cr STEEL (12) Rolled STEEL (13) Cast STEEL (15) Mn-Cu
30	19 93 141	BRONZE (5) Cu-Mn BRONZE (4) Cu-Si NICKEL COPPER (7) Ni-Cu	19 93 141	BRONZE (5) Cu-Mn BRONZE (4) Cu-Si NICKEL COPPER (7) Ni-Cu	103 97 167 94 114 125 169	IRON (11) Ni (Cast) STEEL (12) Rolled STEEL (15) Ni STEEL (13) Cast IRON (11) Si (Cast) STEEL (15) Cr-Si STEEL (15) Ni	124 167 169	STEEL (15) Ni-Cr STEEL (15) Ni STEEL (15) Ni
40	115 20 76 91 151 159	BRONZE (5) Cu-Mn BRONZE (4) Cu-Si BRONZE (5) Cu-Mn BRONZE (4) Cu-Si BRONZE (4) Cu-Si BRONZE (4) Cu-Si	91 102 115 76 9 88 92	BRONZE (4) Cu-Si BRONZE (3) Cu-Sn BRONZE (5) Cu-Mn BRONZE (5) Cu-Mn BRONZE (4) Cu-Si BRONZE (6) Cu-Sn-Zn BRONZE (3) Cu-Sn	170 83 81 98 166 112 127	STEEL (15) Ni STEEL (12) Rolled STEEL (13) Cast IRON (10) Cast IRON (11) Ni (Cast) IRON (10) Cast STEEL (12) Rolled	125 114 94 81 170 97	STEEL (15) Cr-Si IRON (11) Si (Cast) STEEL (13) Cast STEEL (13) Cast STEEL (15) Ni STEEL (12) Rolled
50	88 77 102	BRONZE (6) Cu-Sn-Zn BRONZE (3) Cu-Sn BRONZE (3) Cu-Sn	151 77 20 159 108 15 10	BRONZE (4) Cu-Si BRONZE (3) Cu-Sn BRONZE (4) Cu-Si BRONZE (4) Cu-Si BRONZE (6) Cu-Sn-Zn BRONZE (4) Cu-Si BRONZE (1) Cu-Zn	104 118	IRON (11) Mo (Cast) STEEL (13) Cast	127	STEEL (12) Rolled
60	154 9 15 18 10 107 108	BRONZE (1) Cu-Zn BRONZE (4) Cu-Si BRONZE (4) Cu-Si BRONZE (1) Cu-Zn BRONZE (1) Cu-Zn BRONZE (3) Cu-Sn BRONZE (6) Cu-Sn-Zn	8 18 154	BRASS (1) Cu-Zn BRONZE (1) Cu-Zn BRONZE (1) Cu-Zn	163	IRON (11) Ni-Cu (Cast)	112 98 118 104 163 83 103	IRON (10) Cast IRON (10) Cast STEEL (13) Cast IRON (11) Mo (Cast) IRON (11) Ni-Cu (Cast) STEEL (12) Rolled IRON (11) Ni (Cast)
70	8	BRASS (1) Cu-Zn	107 171	BRONZE (3) Cu-Sn NICKEL COPPER (7) Ni-Cu	80	IRON (11) Ni (Cast)	—	—
80	171	NICKEL COPPER (7) Ni-Cu	100	BRONZE (6) Cu-Sn-Zn	82	IRON (10) Cast	166	IRON (11) Ni (Cast)
90	100	BRONZE (6) Cu-Sn-Zn	—	—	—	—	99	IRON (10) Cast
100	84	BRONZE (6) Cu-Sn-Zn	84	BRONZE (6) Cu-Sn-Zn	105 99 144 113	IRON (10) Cast IRON (10) Cast IRON (11) Ni-Cu (Cast) IRON (10) Cast	113	IRON (10) Cast
110	156 78	NICKEL COPPER (7) Ni-Cu BRONZE (3) Cu-Sn	156 78	NICKEL COPPER (7) Ni-Cu BRONZE (3) Cu-Sn	—	—	144	IRON (11) Ni-Cu (Cast)
120	16	BRASS (1) Cu-Zn	—	—	79	IRON (11) Ni-Cu (Cast)	105	IRON (10) Cast
140	—	—	16	BRASS (1) Cu-Zn	106	IRON (10) Cast	80 79	IRON (11) Ni (Cast) IRON (11) Ni-Cu (Cast)
160	101	BRASS (3) Cu-Sn	101	BRONZE (3) Cu-Sn	—	—	82 106	IRON (10) Cast IRON (10) Cast
180	—	—	17	BRONZE (1) Cu-Zn	—	—	—	—
200	17	BRONZE (1) Cu-Zn	—	—	—	—	—	—
280	7	COPPER (8) Cu	7	COPPER (8) Cu	—	—	—	—

FIG. 10 RELATIVE RESISTANCE SCALE 2 (INITIAL EROSION)
(Initial resistance based on weight loss for initial 30 min period.)

35 per cent of zinc and the remainder iron, manganese, or other materials in varying proportions. Some of these materials, namely, serials 21, 89, and 23, are extremely resistant to cavitation erosion, showing an average weight loss of only 20 mg per hr. Other types of manganese bronze, notably, serials 76 and 115, having lower strength, show an average weight loss of about 50 mg per hr in either fresh water or sea water. There is little or no change in weight loss between fresh and sea water with this material, and it is ranked second in all of the relative-resistance scales for nonferrous materials. Behavior under corrosive conditions has been found uncertain, and care must be used when the fluid is sea water.

Class 6, Bronze (Cu-Sn-Zn). This group comprises the more complex bronze alloys or the leaded bronzes. Serials 84 and 100 are the typical 85-5-5-5 bronze, whereas serial 88 is the standard composition G or Government bronze having 88 per cent of copper, 10 per cent of tin, and 2 per cent of zinc. Serial 108 has approximately the same composition, except that the tin has been reduced to 9 per cent, and the zinc increased to 3 per cent. All four materials have relatively low ultimate strength, and cavitation erosion in fresh water varies from approximately 50 to 85 mg per hr. In sea water, there is a measurable reduction in weight loss for all except serial 108 which shows an increase from about 50 to 65 mg per hr, even though this particular material has a higher ultimate strength that the other three. This group ranks fifth on the relative-resistance scale, except in sea water where it drops to sixth place due to the greater damage to serial 108. This material is easily worked and is readily machinable but does not appear to be as good for portions of the machinery exposed to cavitation as are several other of the classes.

Class 7, Nickel Copper (Ni-Cu). This group comprises alloys of nickel and copper in varying proportions, ranging from 30 per cent of nickel and 70 per cent of copper for serial 156 down to 66 per cent of nickel and 31 per cent of copper for serial 141.

Serial 171 falls about halfway between these two. It would appear that strength is increased materially as nickel content is increased, and cavitation damage is correspondingly reduced. Serial 156 averages about 85 mg per hr with the 30 per cent nickel content, whereas serial 141 loses only 60 mg per hr and has a 66 per cent nickel content. Serials 143 and 142 have approximately 63 per cent of nickel and slightly over 30 per cent of copper, but, in serial 143, about 3 per cent of silicon has been added, and, in serial 142, about 3 per cent of aluminum is present. Serial 142 has an extremely high ultimate tensile strength, ranging up to 150,000 lb per sq in., and its cavitation damage is represented by a weight loss of about 25 mg per hr in either fresh or salt water. Serial 143, however, has an ultimate tensile strength of about 110,000 lb per sq in. but has a cavitation-damage index of only 20 mg per hr as compared with 25 mg per hr for the higher-strength material. This group represents the widest variation in cavitation damage between individual materials and when averaged, falls in third place for resistance to erosion, scale 1, and in fourth place for initial resistance to cavitation damage, scale 2. If serials 142 and 143 alone were considered, they would fall in second place, whereas serials 156 and 171 would fall approximately in fifth place.

Class 8, Pure Metals (Cu). As a basis for comparison, specimens of pure copper were subjected to cavitation testing, and, in fresh water, this material loses about 185 mg per hr and in sea water, about 175 mg per hr. This has not been included in any relative-resistance scales as it was tested for general information only. It indicates that copper is relatively soft and has low fiber and fatigue strengths. When alloyed with very small quantities of silicon, tin, or other materials, the cavitation damage is reduced to one fourth that of the pure material.

Ferrous Materials (Fig. 8)

Class 10, Cast Iron. With ultimate tensile strength varying from 25,000 to 40,000 lb per sq in., cast iron is characterized by lack of uniformity and great increase in cavitation damage in sea water, as compared with fresh water. Maximum weight loss in fresh water is about 95 mg per hr, but this jumps to 115 mg per hr in sea water. Minimum damage is on the order of 50 mg per hr, but this, in turn, increases materially in sea water. In one case, serial 98, the material loses only 50 mg per hr in fresh water, but this increases to 80 mg per hr in sea water. It stands in seventh place on all scales of relative resistance.

Class 11, Alloy Iron. When iron is alloyed with nickel, silicon, or other materials, the strength is increased by a small amount, but the grain structure is greatly improved as cavitation damage is appreciably less than ordinary cast iron and, with few exceptions, the increase in weight loss between fresh and salt water is not as great as with ordinary cast iron.

Class 12, Steel. With rolled and forged steels of ordinary characteristics, without unusual alloying elements, tensile strengths varying from 60,000 up to 85,000 lb per sq in. can be obtained. With one exception, weight loss is between 50 and 75 mg per hr in fresh water but increases appreciably in sea water. This group stands sixth on relative-resistance scale 1 in fresh water and fifth in salt water. Initial resistance to cavitation, scale 2, is greater than cast steels or irons, in so far as fresh-water conditions are concerned, but it is less resistant than cast steel in salt water. Differences in composition between the various steels in class 12 are not very great, and the only distinguishing characteristic of serial 116 seems to be a higher percentage of manganese and a slightly greater carbon content, that is, 0.3 as compared with 0.25 per cent. Serial 83 has a still lower carbon content, 0.2 per cent, while serial 127 has the same carbon content as serial 116 but has no measurable percentage of manganese present. Slight differences in cavitation resistance may be due to varying carbon contents and to small changes in manganese content.

Class 13, Cast Steel. These cast steels are all of good quality having an ultimate tensile strength of 75,000 lb per sq in. They do not differ materially from the rolled steels of class 12 and follow the same general trend of having slightly greater damage in sea water, as compared with fresh water. In general, the characteristics of classes 12 and 13 are very similar, and they stand next to each other on the relative resistance scale, with cast steel showing slightly better resistance than rolled steel in sea water.

Class 15, Alloy Steel. In the alloy steel group, many different compositions are encountered all having less than 5 per cent of either nickel or chromium present. Serials 172 and 165 contain less than 5 per cent of nickel with about 1 per cent of chromium and have very high strength, namely, 150,000 lb per sq in., and show very little damage from cavitation. There is some slight increase from the average of 20 mg per hr loss in fresh water to 23 or 24 mg per hr loss in sea water for these two materials. The remainder of the alloy-steel group average close to 50 mg per hr loss in fresh water and slightly more than that in sea water. Performance of the other six specimens is remarkably uniform, and there are no distinguishing characteristics in either fresh or salt water. Alloy steel stands third on all relative-resistance scales and represents a very satisfactory material for turbine or pump impellers. It shows less cavitation damage than rolled or cast steel where alloying elements are not present.

Class 16, Chromium Steel. This classification includes chromium alloys having varying percentages of chromium in excess of 5 with a negligible percentage of nickel present. All four materials have approximately 12 per cent of chromium, and there are very few differences in their composition. Serial 131 was oil-hardened, whereas serial 128 was hardened by ordinary methods. Brinell hardness runs from 285 up to 375, and Rockwell B hardness is in the neighborhood of 105. Ultimate tensile strength of serial 131, reaches 180,000 lb per sq in., and this particular material is the most resistant to cavitation erosion, scale 1, of any tested, but its initial resistance, scale 2, is not as high as some of the nickel-chromium steels in class 17. On all relative-resistance scales, this material stands second, based upon the average of materials tested. It shows somewhat increased damage in sea water, as compared to fresh water, with a possible exception of serial 128.

Class 17, Nickel-Chromium Steel (Cr-Ni). Nickel-chromium steels represent variations of the so-called stainless steels and are uniformly very resistant to cavitation damage. The maximum rate is on the order of 20 mg per hr and the average, in either fresh or salt water, is slightly under 18 mg per hr. This material stands at the top of all relative-resistance scales, both for uniform erosion, scale 1 and for initial resistance to cavitation damage, scale 2. Ultimate tensile strength varies from 75,000 lb per sq in. to a value in excess of 115,000 lb per sq in. but, for the most part, ranges between 75,000 and 85,000 lb per sq in. The alloy has a dense grain structure and high fiber stress and fatigue limit. The experience record with this material in acutal service in fresh water indicates that it is most satisfactory. It has been found possible to apply a welded coating of nickel-chromium steel to ordinary steel-turbine or pump blades to make them more resistant to cavitation damage. Use of this material in contact with ordinary steel in sea water produces severe electrolytic action and is not recommended for welded coatings. General use of this material in sea water is still open to question as results show in some cases that severe local corrosion has developed rapidly after submergence in sea water. This unsatisfactory performance in sea water has stimulated research work, and improvements in corrosion resistance have been made by changing the chemical composition and by the use of other alloying elements. Before

being used in sea water, special service tests should be made under conditions closely approaching actual operation.

Venturi Tests

As mentioned previously, the original method developed for testing resistance of materials to cavitation was in a venturi-shaped section through which water was passed at an extremely high velocity. To coordinate previous research work with the new vibratory method, the original contract with Massachusetts Institute of Technology contemplated checking six different materials, one specimen in fresh water and two specimens in salt water, to determine whether or not the relative scale of resistance to cavitation would be the same if established by the vibratory method as compared to its development by the venturi method. As the vibratory tests proceeded and the results indicated that the scale of relative resistance was reliable and, also, since the funds available for this investigation were restricted due to the termination of the project, only three materials were tested by the venturi method, and the funds thus released would be utilized for additional tests by the vibratory method. The small venturi machine at the Massachusetts Institute of Technology was to be employed for these tests, and sufficient quantities of sea water from Cobscook Bay shipped to Cambridge for this purpose.

Careful study of the behavior of the smaller venturi apparatus indicated that its use would require a much longer time for the investigation than was available, but, if the larger venturi machine was employed, the time element could be reduced greatly, and special castings or rolled plates needed for the smaller apparatus would become unnecessary. There was sufficient material remaining from the vibratory tests to prepare duplicate specimens for the large venturi tests. This represented a distinct advantage in that identical materials were investigated in both types of apparatus.

The venturi specimen consisted of a flat disk, $1^1/_4$ in. in diameter and approximately $^1/_4$ in. thick, which was fastened by three screws to a holder inserted in the throat of the venturi apparatus. These specimens were prepared in the laboratory machine shop and were polished to give the same surface conditions as with the vibratory apparatus.

Three materials were selected; namely, cast iron, class 10, serial 82; cast steel, class 13, serial 118; and manganese bronze, class 5, serial 76; after a careful study of their behavior in sea water in the corrosion laboratory at Eastport. They occupied widely separated positions on the scale of relative resistance and, at the same time, were materials that were frequently employed for hydraulic-turbine runners and pump impellers. A supplementary test covering the behavior of nickel-chromium steel, class 17, serial 132, was conducted in fresh water only.

Artificial Sea Water

The quantity of water required for tests in the large venturi apparatus was very large, approximately 5 tons, and precluded the idea of utilizing water taken from Cobscook Bay. During the investigations, various synthetic sea-water solutions were prepared and tested in comparison with natural sea water and ordinary fresh water. A special solution, used in the venturi-test program, simulated very closely the water taken from Cobscook Bay.

It was found that Turk's Island salt was available in Eastport, and a large sample was obtained for test purposes. This salt is prepared from sea water by evaporation and approximates closely the chemical composition of the salt in natural sea water but is deficient in a few constituents. The chemists in the Concrete Laboratory prepared a synthetic sea water based upon the use of Turk's Island salt to give a solution having the same density as natural sea water; namely, 1.023. This Turk's Island sea water gave less damage in the vibratory apparatus than did the natural sea water drawn from Cobscook Bay. Several variations of chlorine content were tried, and the final solution was prepared with the following percentages of the various types of salt:

	Per cent
Turk's Island salt	53.6
Sodium chloride	32.5
Magnesium chloride	7.13
Magnesium sulphate	5.7
Calcium chloride	1.07

The density of this solution was 1.0237 as compared with 1.023 for natural sea water.

To correlate the two methods more carefully, samples of the artificial sea water were withdrawn from the venturi apparatus during the test, and additional vibratory tests made on the same materials in this artificial sea water to check the behavior against the previous vibratory investigation in natural sea water (Fig. 5). The solution causes about the same damage as does natural sea water, except in the case of cast iron where some decrease in the damage was found. In general, the artificial sea water can be considered the test equivalent of natural sea water and the results obtained in the venturi apparatus utilized without danger of incurring any serious error.

Comparison Between Venturi and Vibratory Methods

The venturi method had been used previously in determination of the relative resistance of different materials to cavitation erosion. Attempts have also been made with some degree of success to correlate the data obtained from different venturi-testing units. It has been found that the form of profile, size of unit, air content and temperature of the fluid, velocity of flow, and absolute pressure at the venturi throat have a direct bearing upon the amount of cavitation damage occurring on the test specimens.

With the vibratory apparatus, however, no such basis of previous experience is available. Except for the check tests on cast iron, cast steel, and bronze in the venturi apparatus at Massachusetts Institute of Technology, no comparison between the two methods has been made.

Comparison of weight loss on the various materials tested by the vibratory method with weight loss on the same materials tested by the venturi apparatus indicated immediately that the two series of investigations cannot be compared directly unless some other factor, such as time or frequency of vibration, is considered. Detailed study of results by the two methods was made in an endeavor to correlate them in some reasonable manner.

Comparison of Weight Loss per Unit Area

The first step in securing this comparison was to reduce all readings of weight loss to a common basis of weight loss per unit area. The range between maximum and minimum curves in the venturi apparatus was much greater than in the vibratory apparatus. It was found that weight loss per unit area per unit time showed the same discrepancies, and the ratio between the values in the two types of equipment showed that rate of weight loss per hour in the vibratory apparatus was about 45 times that in the venturi apparatus. This was about one third the ratio of the frequencies.

Frequency of the vibratory apparatus was 6690 cycles per sec. Calculated frequency of the venturi apparatus was 47 cycles per sec, and measurements made in the venturi tests confirmed this value as being in the neighborhood of 50 cycles per sec. The ratio between the two frequencies is about 140 which would indicate that the vibratory apparatus would produce the same

number of cavitation blows in $^1/_{140}$ of the time required in the venturi apparatus.

A new unit of measurement, "weight loss per unit area per million blows," was then used and designated as W. These values still showed a marked discrepancy between the two methods, but, if the damage W at the end of a given number of blows is compared for the same material in the two different types of tests, still another ratio, S, called for convenience "the relative-intensity ratio," is possible.

While this ratio S varies with different types of materials, due probably to the differential existing between the ultimate

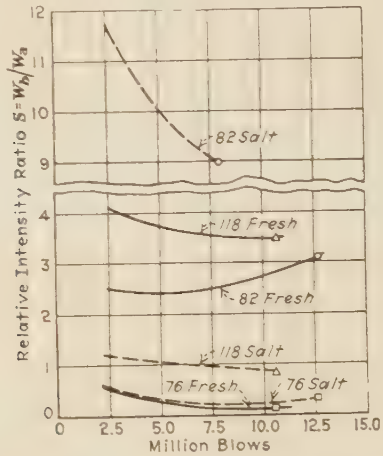


FIG. 11 RELATION BETWEEN VIBRATORY AND VENTURI RESULTS

strengths of the materials and the stress imposed by the cavitation blow, there was a marked uniformity for a given material. As shown in Fig. 11, the ratio S remains practically constant for the range up to between 10,000,000 and 12,000,000 blows, with the exception of the cast-iron specimen in salt water. Severe corrosion on the venturi test may account for this.

Investigation was also made comparing rates of change of cavitation damage, which would be indicated as R, being the ratio of the incremental weight losses obtained as the first differential of the weight-loss curves. This study showed no major departure from results secured by use of the relative-intensity ratio S.

Relation Between Vibratory and Venturi Methods

It will be seen that a direct relation between the two methods is not possible from the meager test data now available from the venturi tests of the three materials investigated. It is gratifying to note, however, that, in both vibratory and venturi tests, the relative positions of the different materials are the same with respect to each other, bronze being the most resistant, steel second, and cast iron third. The relative-resistance rates (Table 6) are compared with cast iron in fresh water.

TABLE 6 COMPARISON OF RELATIVE RESISTANCE BY VIBRATORY AND VENTURI METHODS

		Vibratory		Venturi	
	Material	Fresh water	Sea water	Fresh water	Sea water
76	Bronze	1.6	1.5	60.0	55.0
118	Cast steel	1.2	0.95	1.6	5.6
82	Cast iron	1.0	0.54	1.0	0.2

Appearance of the individual specimens indicates that the action in the venturi apparatus is proceeding at a much slower rate than is the case with the vibratory testing. In the venturi tests, the bronze and stainless-steel specimens give the appearance of severe hammering having taken place on the surface. As the test continued, these surfaces gradually assumed a pitted appearance. At the end of 60 or 80 hr, a pronounced change in the surface could be detected, and numerous pits were present. This is equally true of stainless steel, serial 132, except that the pits were few in number and relatively small in size.

In the case of cast iron, which is brittle and not ductile, the initial stage is practically nonexistent, and pitting action begins at once. With cast steel, some plastic deformation takes place in initial stages of exposure to cavitation action, but the metal did not retain its fiber strength for as long a period as certain nonferrous materials.

Combined with the action of cavitation damage, there was also the corrosive action of sea water, which, in the venturi apparatus, apparently increased the damage due to longer exposure of the specimen to sea water, permitting the chemical action to become further advanced. This is particularly noticeable with respect to serial 82, cast iron, in sea water as compared with fresh water.

Plastic Deformation and Pitting

Considering only cavitation action independent of corrosive action, it would appear that work hardening or plastic deformation takes place on those materials which are ductile. The second action, indicated as pitting, apparently takes place only after the fatigue limit or ultimate strength of the fibers has been reached.

It is probable that the intensity of the blow in the vibratory apparatus is greater than is found in the venturi apparatus with the result that the work-hardening and plastic-flow period may be passed in a relatively few minutes, and, in some cases, the blow intensity is so great that the ultimate strength of the fibers is exceeded at once, in which case the pitting stage is reached immediately.

Conclusions

(1) The conclusions to be drawn from this investigation must be qualified by considering the behavior of the various materials in sea water in the first two phases of the corrosion investigation, namely, pure corrosion and electrolysis. Many high-strength materials have not indicated satisfactory behavior in sea water at Eastport.

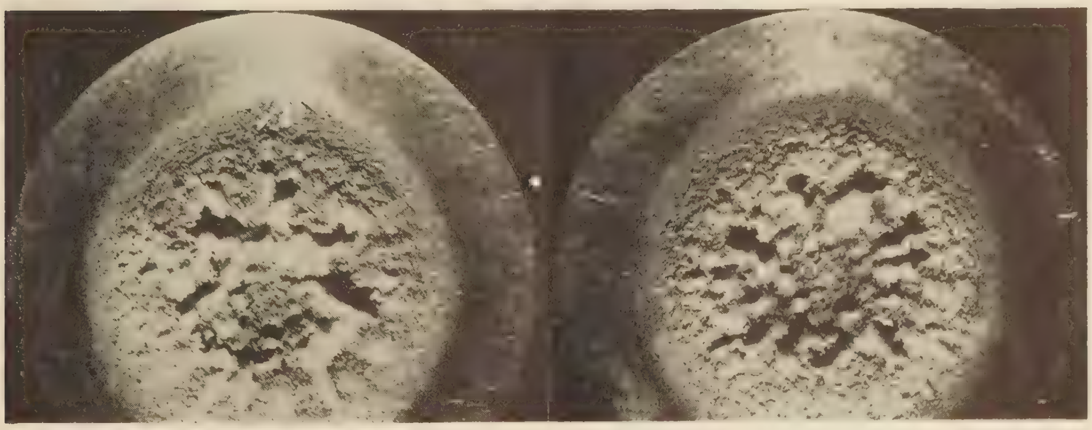
(2) In so far as application to hydraulic turbines, pumps, and other machinery operating in fresh water under conditions where cavitation will exist, various materials can be selected with reasonable assurance from the scale of relative resistance developed for fresh water. The consolidated-resistance scale for both cavitation erosion and initial resistance to cavitation can be found in Figs. 9 and 10, where individual materials are listed in the order of their loss of weight in the vibratory apparatus.

(3) Where equipment is to be operated in salt water or in contaminated water which would have a corrosive action, or where material is subjected to electrolysis due to its being in contact with some dissimilar material, the cavitation-resistance scales alone are not reliable, and it is necessary to have the comparative data upon the corrosion and electrolysis behavior of the materials in the particular fluid under consideration.

(4) From a comparison of results of the venturi tests with the vibratory tests, it is evident that the same relative behavior is found in the two methods. However, the vibratory test represents a much accelerated condition, and the 90-min test period offers little time for chemical action to become effective. The venturi method allows more time for chemical reactions to take place, and the greater damage to cast iron in salt water is probably due to the chemical action assuming substantial proportions as compared with pure cavitation erosion. Actual service conditions may produce greater relative damage in sea water than was

Fresh water Sea water

FIG. 12 RESULTS OF VIBRATORY TEST OF BRASS, CLASS 1, SERIAL 10
(Best results for class 1.)

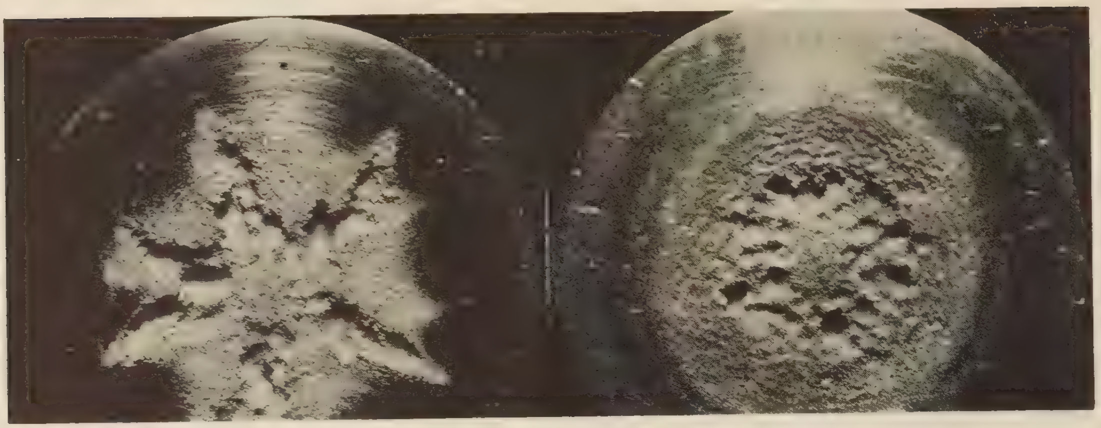


Fresh water Sea water

FIG. 13 RESULTS OF VIBRATORY TEST OF BRASS, CLASS 1, SERIAL 17
(Poorest results for class 1.)

Fresh water Sea water

FIG. 14 RESULTS OF VIBRATORY TEST OF ALUMINUM BRONZE, CLASS 2, SERIAL 24
(Best results for class 2.)

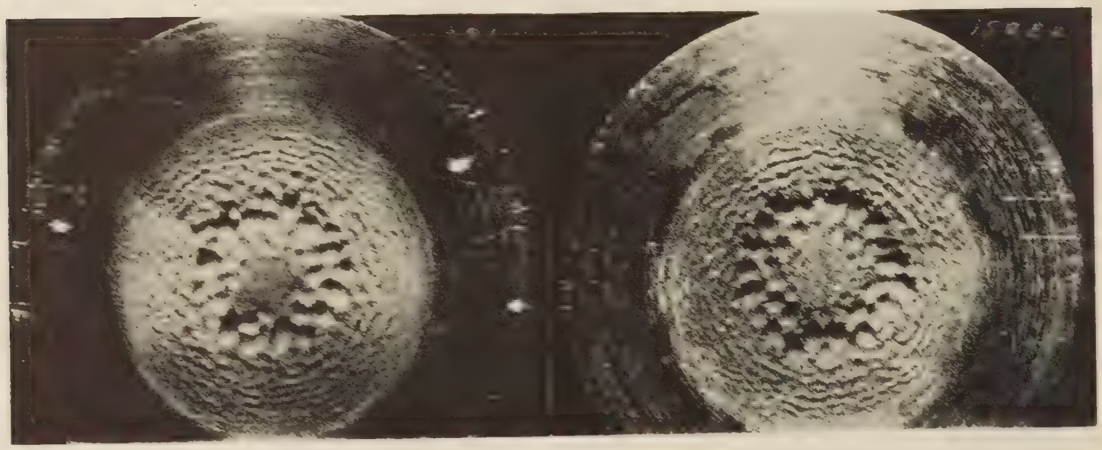


Fresh water Sea water

FIG. 15 RESULTS OF VIBRATORY TEST OF BRONZE (Cu-Sn), CLASS 3, SERIAL 102
Best results for class 3.)

Fresh water Sea water

FIG. 16 RESULTS OF VIBRATORY TEST OF SILICON BRONZE, CLASS 4, SERIAL 93
(Best results for class 4.)

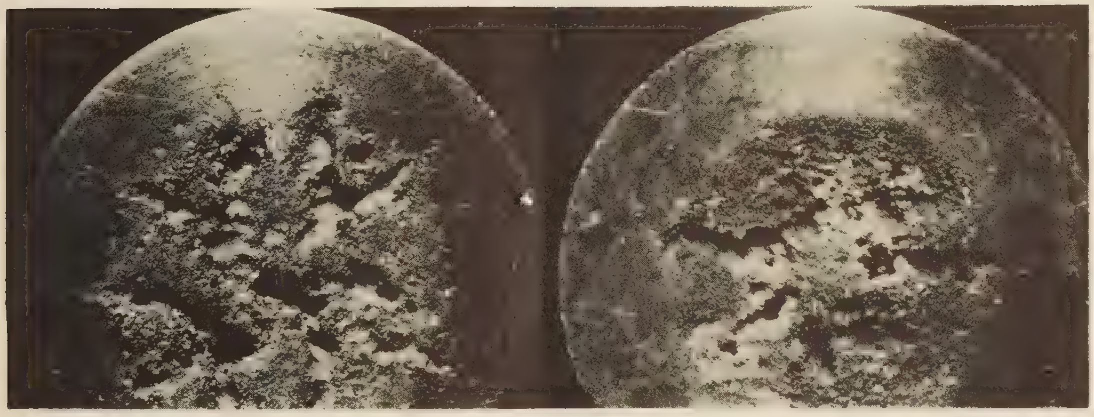


Fresh water Sea water

FIG. 17 RESULTS OF VIBRATORY TEST OF SILICON BRONZE, CLASS 4, SERIAL 159
(Poorest results for class 4.)

Fresh water Sea water

Fig. 18 Results of Vibratory Test of Manganese Bronze, Class 5, Serial 23
(Best results for class 5.)



Fresh water Sea water

Fig. 19 Results of Vibratory Test of Bronze (Cu-Sn-Zn), Class 6, Serial 108
(Best results for class 6.)

Fresh water Sea water

Fig. 20 Results of Vibratory Test of Nickel-Copper, Class 7, Serial 143
(Best results for class 7.)

Fresh water Sea water

Fig. 21 Results of Vibratory Test of Copper, Class 8, Serial 7

Fresh water Sea water

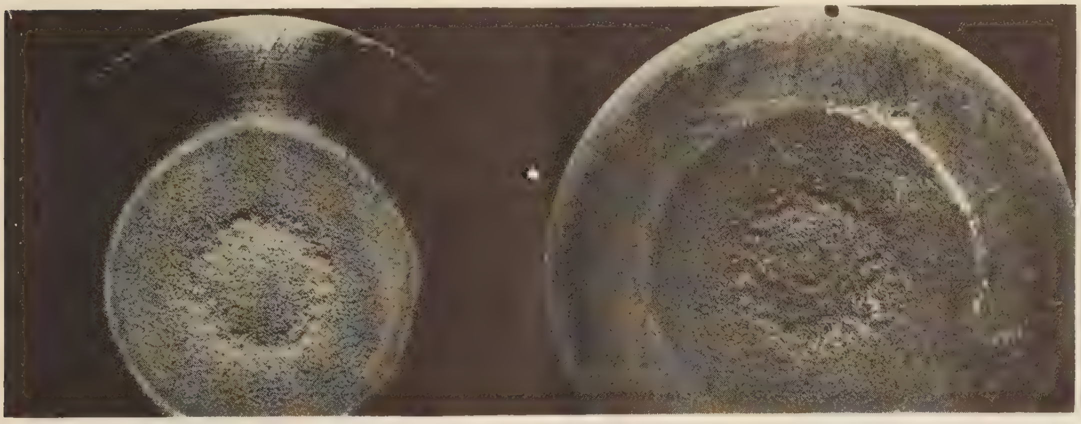
Fig. 22 Results of Vibratory Test of Iron, Class 10, Serial 98
(Best results for class 10.)

Fresh water Sea water

Fig. 23 Results of Vibratory Test of Iron, Class 10, Serial 106
(Poorest results for class 10.)

Fresh water Sea water

Fig. 24 Results of Vibratory Test of Alloy Iron, Class 11, Serial 163
(Best results for class 11.)

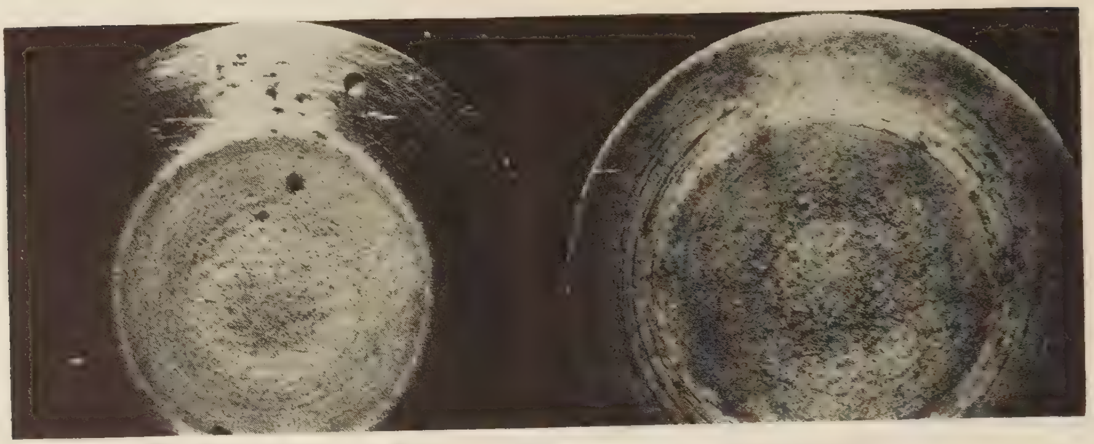


Fresh water Sea water

Fig. 25 Results of Vibratory Test of Steel, Class 12, Serial 116
(Best results for class 12.)

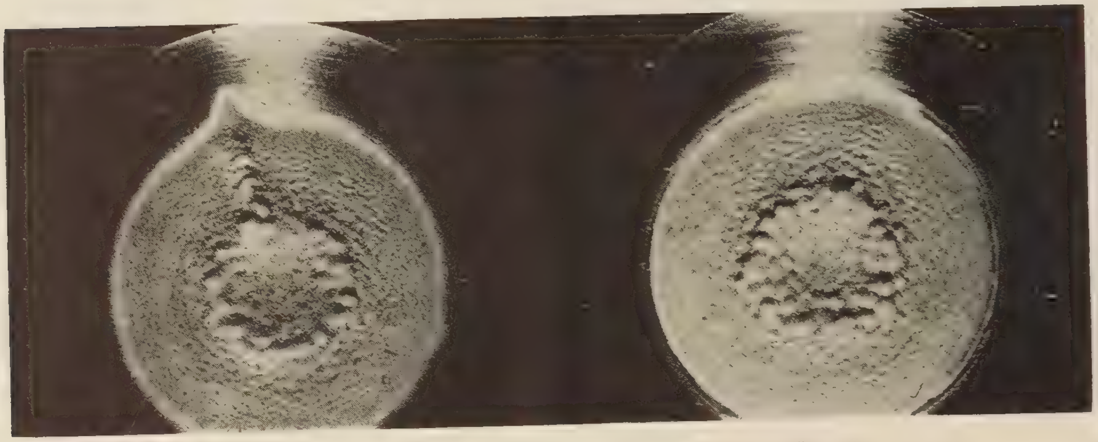
Fresh water Sea water

Fig. 26 Results of Vibratory Test of Cast Steel, Class 13, Serial 119
(Best results for class 13.)



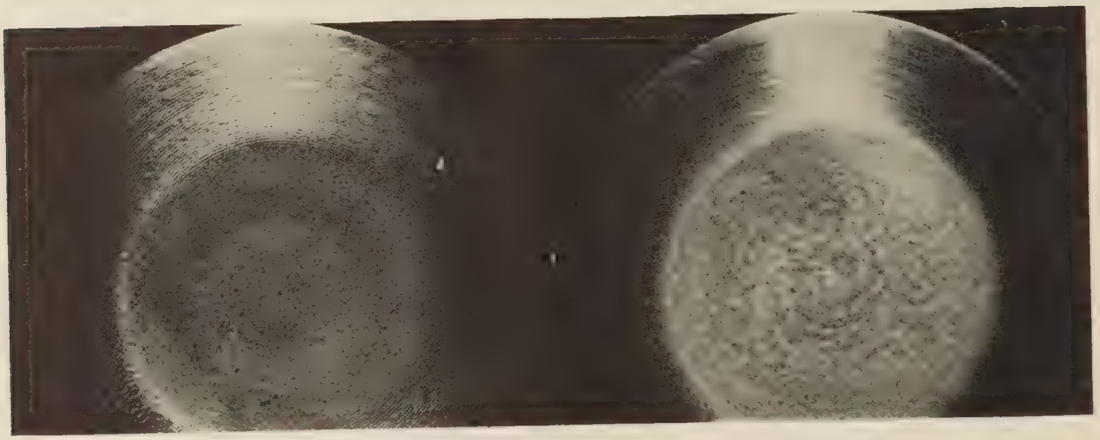
Fresh water Sea water

Fig. 27 Results of Vibratory Test of Alloy Steel, Class 15, Serial 165
(Best results for class 15.)



Fresh water Sea water

Fig. 28 Results of Vibratory Test of Alloy Steel, Class 15, Serial 170
(Nonuniform results.)



Fresh water Sea water

Fig. 29 Results of Vibratory Test of Chromium Steel, Class 16, Serial 131
(Best results for class 16.)

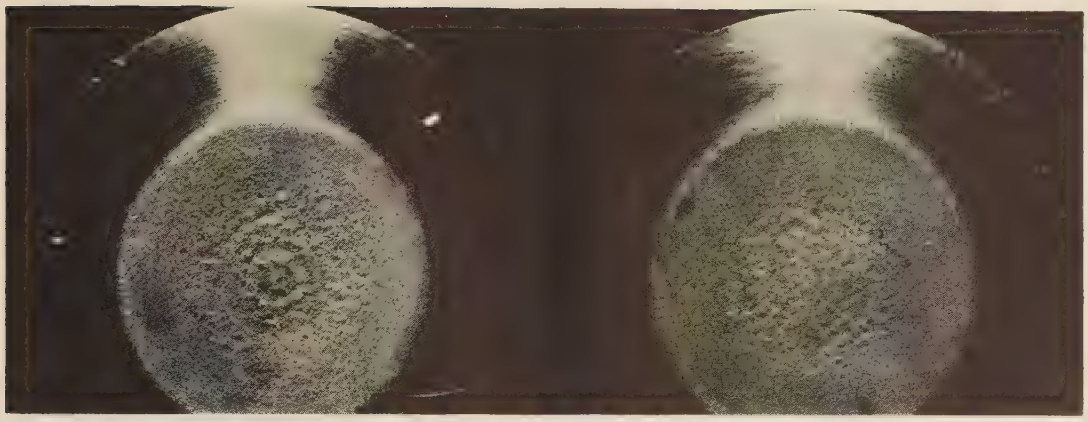


Fig. 30 Results of Vibratory Test of Nickel-Chromium Steel, Class 17, Serial 173
(Best results for class 17.)

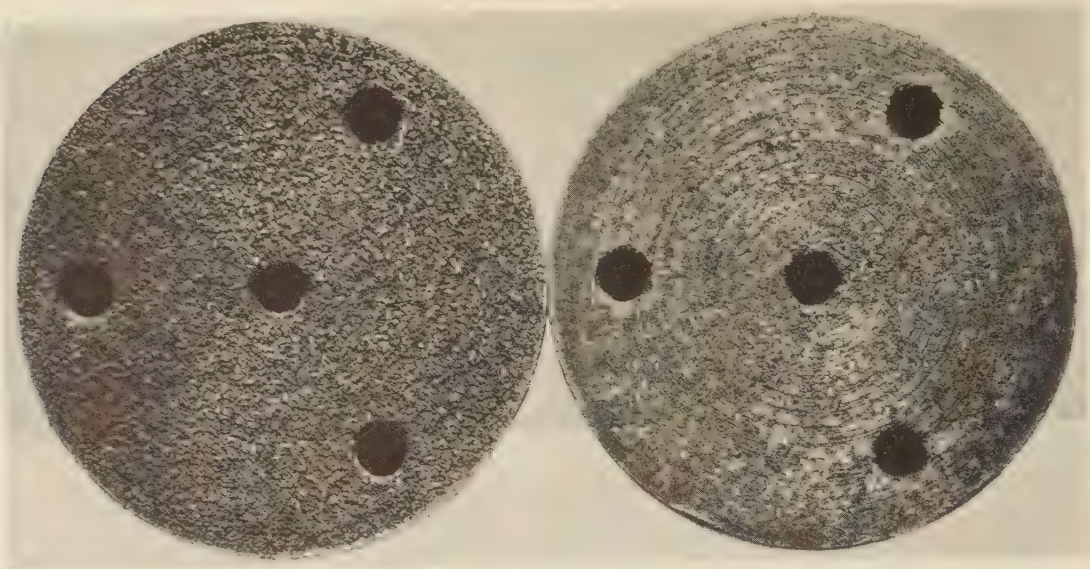
Fig. 31 Results of Venturi Test of Bronze, Class 5, Serial 76

indicated by vibratory tests, particularly with regard to ferrous materials.

(5) Analysis of an independent set of tests previously made in a venturi apparatus for one of the organizations supplying material for this program indicated that the same relative-resistance scale as developed by the vibratory apparatus holds approximately true with the venturi apparatus and, hence, relative performance of the two sets of apparatus can be relied upon to give reasonably satisfactory results.

(6) Comparison between natural sea water and artificial sea water as shown in Fig. 5 indicates that synthetic water in the venturi apparatus caused slightly less proportional damage in the case of cast iron than did natural sea water, whereas it caused slightly more damage with the cast-steel specimens. In all three cases, water drawn from the venturi apparatus and used in vibratory tests at 34 C show slightly more damage than in fresh-water tests at 25 C. By comparison, therefore, it would appear that cast iron as tested with synthetic sea water would not show as much damage as with natural Quoddy water. In the venturi apparatus, a slightly greater differential between fresh and sea water would have been found if it had been possible to use natural instead of artificial sea water. The discrepancies are not sufficient to change the conclusions or to change the scale of relative resistance.

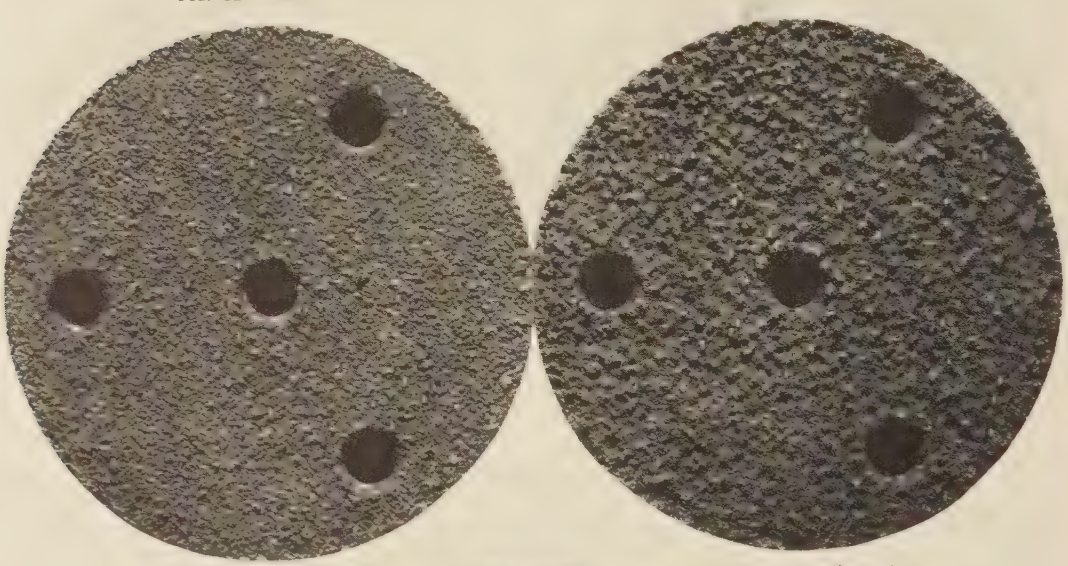
(7) Recommendations in regard to the specific materials to use in turbines, pumps, and other similar equipment are beyond the scope of this paper. In cases where fresh and noncorrosive water is available, such as exists in the majority of water-works pumping plants or in almost all hydroelectric plants, the scale of relative resistance (Fig. 10) determined for fresh water should be a reasonably accurate guide to the selection of proper materials. If a cheaper material can be coated with a more resistant metal by welding or other means, then the coating metal can be selected in the same manner.



Fresh water

Sea water

Fig. 32 Results of Venturi Test of Cast Steel, Class 13, Serial 118



Fresh water

Sea water

Fig. 33 (Above) Results of Venturi Test of Cast Iron, Class 10, Serial 82

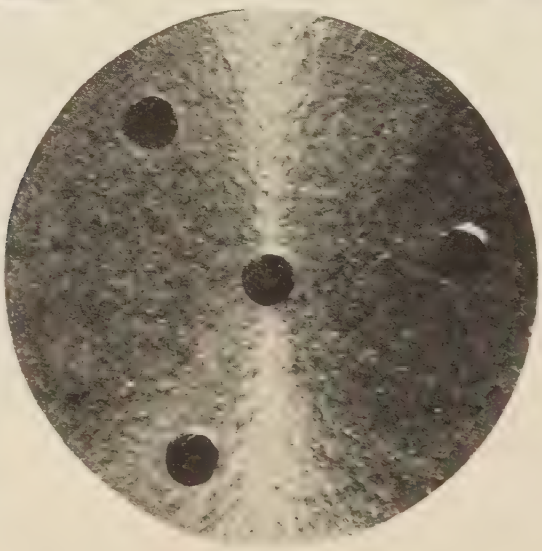


Fig. 34 (Left) Results of Venturi Test of Nickel-Chromium Steel, Class 17 Serial 132

Fresh water

(8) Where a corrosive fluid is encountered, be it sea water in its various conditions of purity or contamination, or some alkaline or acid water, or a corrosive solution in a chemical plant, the proper material can be selected only after a series of corrosion tests under actual conditions or from a long and comprehensive set of experience records. Too much emphasis cannot be placed upon the rapid deterioration of structures and equipment exposed to corrosion or electrolysis. The method of protecting cast-steel turbine runners with a local coating of nickel-chromium or other corrosion-resistant steel cannot be used where sea water is present due to the severe electrolytic action that takes place between these two materials.

Acknowledgments

The Passamaquoddy Tidal Power Project was carried on by the Corps of Engineers of the U. S. Army. Lieut.-Col. Philip B. Fleming was district engineer at Eastport, Me., and Capt. Hugh J. Casey was in charge of engineering design, assisted by Paul F. Kruse, head engineer.

The materials-corrosion investigation was instituted by the writer as senior mechanical engineer, assisted by Edward Hutchins, associate engineer. Harold A. Scott was resident engineer for the Eastport district at the Massachusetts Institute of Technology during the conduct of the tests. Particular credit should be accorded to Dr. J. C. Hunsaker, head of the mechanical-engineering department, and Dr. H. Peters, professor of hydraulics and aerodynamics at Massachusetts Institute of Technology, in working out the details of this new method of test and for their courage in accepting a contract to perform such a comprehensive series of tests under conditions that represented so radical a departure from accepted practice. Their assistants should be commended for their spirit of cooperation and for carrying out the actual test work in a highly satisfactory manner.

The writer is personally indebted to the executives of the Eastport district for official permission to publish the results of this most interesting problem in research.

The conclusions expressed herein are the writer's individual opinions and should not be considered as official statements of the U. S. Engineer Department.

Pitting Resistance of Metals Under Cavitation Conditions

By J. M. MOUSSON,[1] BALTIMORE, MD.

The paper describes the experimental apparatus and testing procedures used to determine the pitting resistance of metallic materials under accelerated cavitation conditions. The results of this research, sponsored by the Safe Harbor Water Power Corporation, are compiled in a series of tables and the classification of metals is discussed in the light of the metallurgical data made available for the materials and the metallographic analysis carried out in connection with the research program. The conclusion is reached that a more rational approach has been provided for selecting materials subject to attack by cavitation.

Introduction

THE PROPER selection of materials for hydraulic equipment exposed to cavitation is still exceedingly difficult in many instances in spite of the fact that pitting has been discussed rather frequently in the past. It has been generally recognized that the main obstacles to a more rational approach were the absence of truly comparative data on the pitting resistance of an adequate number of materials, which may be given consideration in the course of manufacture and maintenance of hydraulic machinery, and the lack of definite information regarding those alloy characteristics influencing the resistance of materials, as well as the nature of their failure when exposed to the punishment under consideration.

Recognizing the need for further progress, the Safe Harbor Water Power Corporation decided in 1934 to sponsor a research program with the following objectives:

(a) To make a standard loss determination on a large variety of metals in cast, rolled, forged, welded, and sprayed conditions, when exposed to cavitation artificially produced by a testing apparatus.

(b) To study the nature of the failure and to determine, if possible, those material characteristics, controllable or uncontrollable, influencing the resistance of the materials.

(c) To compare pitting due to cavitation, and erosion due to water jet, to see whether or not the results obtained with the cavitation test stand can be used as a basis for selecting materials to withstand both types of stress application.

Cavitation Apparatus

With the test stand as shown in Fig. 1, a zone of cavitation was produced by means of a double weir arrangement. This general type of design, originally developed by Walchner, found practical application for the tests carried out by Schröter at the Walchensee development (1).[2] Its advantages over venturi profiles, or sections with protruding obstructions were the rather limited expanse of the cavitation zone, and the accelerated pitting conditions, two factors particularly desirable with a view to the size of the specimens and the duration of the test runs, respectively. In addition to some minor changes in the weir shapes and orifice dimensions, a major modification was made in the location of the specimens. In the original design by Walchner a single specimen was placed opposite the guiding weir, while the apparatus finally adopted for these tests provided for two specimens inserted in the parallel side walls opposite each other. This permitted the testing of duplicate specimens simultaneously, and gave a higher degree of test accuracy without increasing the number of runs. The new location for the specimens was also desirable because pitting was found to be far more severe on the side walls than at the bottom opposite the guiding weir. At the same time there could be no doubt that, at the new location the specimen was less subject to the direct impingement of the fluid which produces impact stresses superimposed on those exerted by cavitation. The dimensions of the specimens were $4 \times 1^1/_4 \times {}^1/_4$ in. (Fig. 2).

To accelerate the test conditions sufficiently a high head had to be provided, and the apparatus was therefore installed at the Holtwood Steam Station of the Pennsylvania Water & Power Co., where a maximum head of 1250 ft could be made available by using a raw-water pump and a boiler feed pump in series.

For ordinary testing, fresh raw water from the forebay of the Holtwood Hydro Station was supplied continuously to the test stand and wasted into the tailrace. For special purposes, however, a recirculating system was installed. The pressure upstream and downstream of the test stand could be regulated by the speed of the boiler feed pump and by a valve, respectively. Based on the results of the calibration runs shown in Fig. 3, standard testing procedures were adopted using a head pressure of 480 lb per sq in. and a back pressure of 25 lb per sq in. The duration of each run was 16 hr. The amount of pitting was determined by weighing the specimens before and after the test. For comparative purposes, however, the loss in volume was used to compensate for the difference in specific gravity of the various materials.

The influences of variation in water temperature and air content were also investigated. As may be seen from Fig. 4, the losses obtained at various temperatures of the available seasonal range, with specimens of rolled, stainless, 18-8 chromium-nickel steel of a particular analysis, were not constant but, for all practical purposes, directly proportional to the vapor pressure. This characteristic was confirmed by tests carried out with the recirculating system where the temperature could be controlled artificially. Under the same conditions, repeat tests were made using boiler-plate steel, sheet brass, rolled-copper bus bar, and three different types of welding deposits, in which the same characteristic was indicated. Because of the temperature effect all

[1] Hydraulic Engineer, Safe Harbor Water Power Corporation. Mem. A.S.M.E. The author was graduated in 1926 from the Swiss Federal Institute of Technology, Zurich, Switzerland. He was designing engineer with the Pennsylvania Water & Power Company and the Electric Bond and Share Company in 1928 and 1929. Since that time he has served on the engineering staff of the Safe Harbor Water Power Corporation as designing, sponsor, and hydraulic engineer.

Contributed by the Hydraulic Division and presented at the Joint Meeting of the Hydraulic and Applied Mechanics Divisions of The American Society of Mechanical Engineers, at Cornell University, Ithaca, New York, June 25–26, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until September 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

[2] Numbers in parentheses refer to Bibliography at the end of the paper.

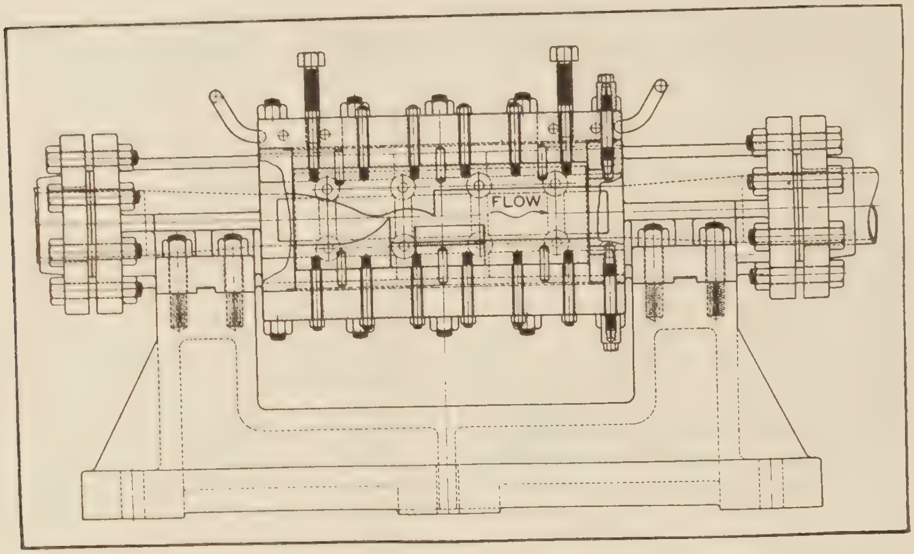


Fig. 1 Holtwood Cavitation Test Stand
(Scale: 1 in. = 10 in.)

Fig. 2 Typical Cavitation Specimen
(Specimen No. 97, Table 6. × 1¼.)

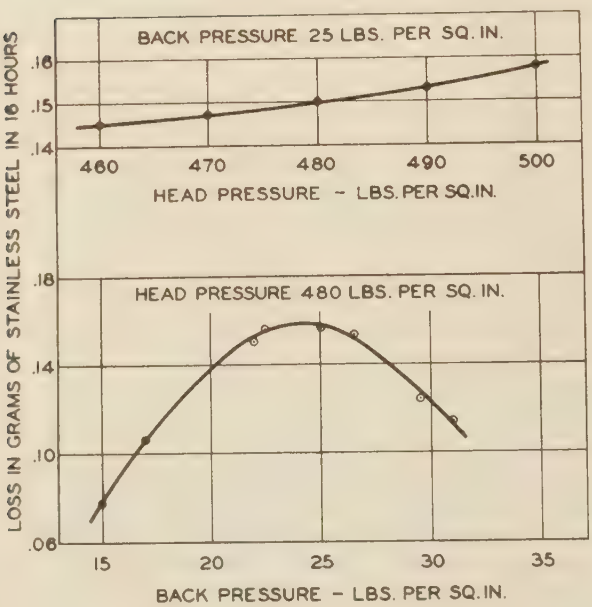


Fig. 3 Calibration of Test Stand

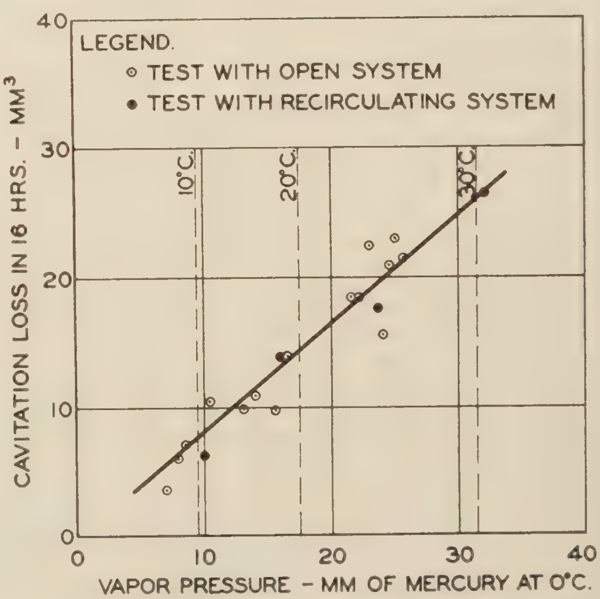


Fig. 4 Effect of Temperature on Pitting

losses were corrected by an amount based on the ratio of the vapor pressures at test temperature and at a common temperature arbitrarily assumed to be 20 C.

As may be seen from Fig. 5, the tests with artificial air injection indicated that with a head pressure of 480 lb per sq in. (throat velocity 265 fps) more than one per cent of air was required above the natural air content of the water to produce a cushioning effect of sufficient magnitude to reduce pitting by an appreciable amount. Since the natural air-content variations could be expected to be less than one per cent no correction needed to be applied to compensate for this seasonal effect under the testing conditions adopted.

Results of Research

A *Metallurgical Aspects of Failure Due to Cavitation*

Prior to this research, it had already been recognized that failure caused by cavitation was primarily mechanical. At the same time three different theories had been developed relating the pitting resistance either to the corrosion-fatigue limit (2), the Brinell hardness (1), or to the tensile strength (3), but inconsistencies left the field wide open to speculation.

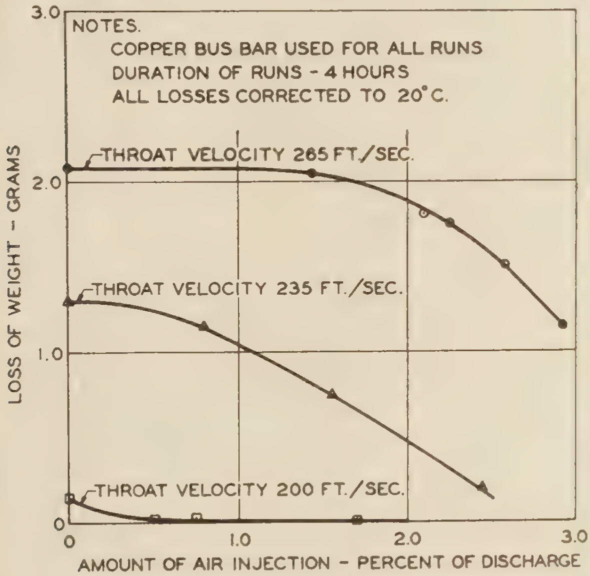


Fig. 5 Effect of Air Content on Pitting

Based on the photomicrographic analysis of many specimens in the course of this investigation, it may be concluded that with regard to the mechanical failure, the following alloy characteristics are of influence: Yield point, capacity of deformation or yield absorption, tensile strength, fatigue properties, original hardness, cold working qualities or susceptibility to strain hardening, grain size, grain boundaries, grain shape, grain structure, distribution of alloy constituents, chemical composition, impurities, and crystallographic properties. Although one or another of the above characteristics may be predominant with regard to the resistance of one particular material, nevertheless it should be borne in mind that all other characteristics contribute their share in any case and are of vital importance particularly when the individual influences are combined to a composite effect.

Some pertinent facts pertaining to the metallographic phase of this research have been published previously (4, 5). It may suffice to say that two types of failure were indicated:

(*a*) Failure due to successive deformations in the zone of highest stress concentration after the capacity of yield has been exhausted (Fig. 6).

(*b*) Failure due to fatigue beneath the zone of possible yield where some stress distribution has already taken place. The separations in this zone may be typical fatigue or cleavage cracks (Fig. 7).

The relationship of yield point, capacity of deformation, and fatigue limit differ in various materials and, depending upon these, as well as upon the severity of cavitation, one or another type of failure may predominate. Yield point, capacity of deformation, tensile strength, and fatigue limit may be termed primary influences as these physicals have direct bearing upon the nature of the failure. All other alloy characteristics referred to above may be termed secondary, not with regard to their importance, but because they do not change the nature of the failure. The importance of the secondary influences can best

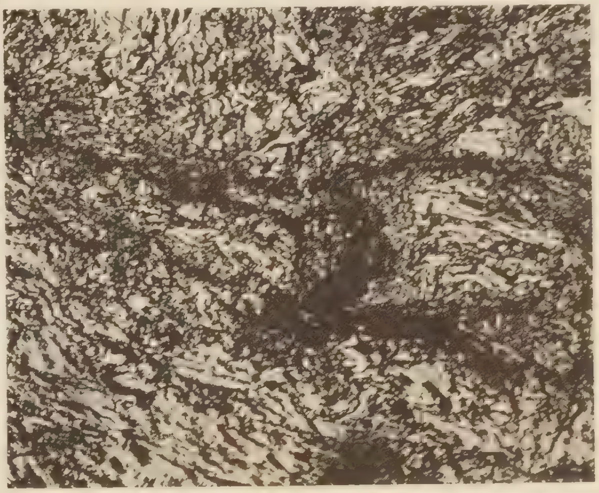


Fig. 6 Plastic Deformation in Zone of Yield
(Copper bus bar. ×200.)

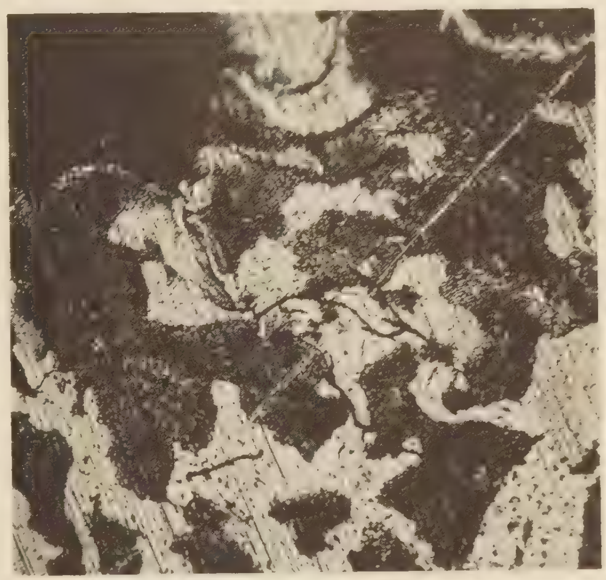


Fig. 7 Fatigue Cracks in Safe Harbor Turbine Steel
(Specimen No. 10, Table 2. ×500.)

TABLE I PLAIN AND ALLOYED CAST IRONS

No.	Alloy	Chemical Composition - Percentage of							Condition	Physical Properties		Cavitation Loss in 16 hrs. mm³ at 20°C
		Total C	Mn	Si	Ni	Cr	Cu			Tensile Strength Lbs./Sq. in.	Brinell Hardness	
1	Cast Iron	3.18	.50	2.13				a	As Cast	25,000	171	636.0
2	Cast Iron with Casting Skin	3.20	.50	2.00				e	As Cast	25,000	200	396.0
3	Nickel-Tensyleron	2.54	.76	2.51	1.05			a	As Cast	56,000	235	376.0
4	5% Nickel Cast Iron	2.93	.50	1.36	4.81			a	As Cast	35,000	303	269.0
5	Ni Cu Cast Iron	3.10*	1.50*	2.00*	15.00*	1.00	7.00*	e	As Cast	18,000	107	837.0
6	Ni Cr Cu Cast Iron	2.77	1.00	1.86	14.48	1.88	6.00	a	As Cast	25,000	116	247.0
7	Ni Cr Cu Cast Iron	2.95	1.00	1.89	14.36	3.95	6.00	a	As Cast	35,000	161	109.0

a: Actual Analysis e: Estimated Analysis * Maximum

TABLE II. CAST LOW ALLOYED STEELS

No	Alloy	Chemical Composition - Percentage of										Condition	Heat Treatments						Typical Physical Properties					Cavitation Loss in 16 hrs. mm³ at 20°C.
		C	Mn	P	S	Si	Ni	Cr	Mo	V			Temp Heated Deg F	Time Held Min	Cooled In	Drawing Temp Deg F	Time Held Min	Cooled In	Tensile Strength Lbs./Sq. In.	Yield Point Lbs./Sq. In.	Elongation in 2 Inches %	Reduction of Area %	Brinell Hardness	
10	.33% Carbon Steel (1)	33	71	.032	030						a	Annealed	1620	360	Furnace				70,250	38,900	35.0	47.2	159	62.4
11	Mn Steel	45	1.51			47					a	Quenched and Drawn	1725	90	Air	1225	240	Furnace	120,000	85,000	12.0	18.0	208	104.0
12	Mn Steel	.45	1.51			.47					a	Quenched and Drawn	1725	90	Air	1175	120	Air	140,000	100,000	18.0	30.0	285	79.6
13	.29% Carbon Steel (2)	.29	.80	.020	.020	.23	.28				a	Annealed and Drawn	1650		Furnace	800			71,500	48,000	32.0	49.8	133	57.8
14	Mn Ni Steel	.29	1.19	.032	.032	.36	1.55	.02			a	Quenched and Drawn	1600		Air	1250		Air	88,000	60,000	28.0	45.0	164	51.1
15	Ni Steel	.30	.70			.40	3.00				e	As Cast											194	42.1
16	Cr Steel	.20	.78			.48		1.68			a	Quenched and Drawn	1750	90	Oil	1175	120	Air	125,000	100,000	16.0	35.0	293	37.1
17	Mn Mo Steel	.29	1.28			.43			.13		a	Quenched and Drawn	1725	90	Air	1250	120	Air	85,000	55,000	22.0	40.0	162	152.0
18	Mo Steel	27	.75						.52		e	Quenched and Drawn	1700		Air	1250		Air	85,000	55,000	20.0	30.0	192	73.6
19	Ni Cr Mo Steel	.28	.65				1.37	.60	.25		e	Quenched and Drawn	1700		Air	1250		Air	85,000	55,000	18.0	30.0	179	54.8
20	Ni Cr Mo Steel	30	65				2.00	.75	.25		e	Quenched and Drawn	1700		Air	1250		Furnace	100,000	65,000	18.0	30.0	188	41.7
21	Ni Cr Mo Steel	.31	.75			45	2.15	.76	.15		a	Quenched and Drawn	1725	90	Air	1225	120	Air	105,000	70,000	20.0	32.0	201	30.7
22	Cr Mo Steel	.51	1.37			.48		1.11	.50		a	Quenched and Drawn	1725	90	Air	1200	120	Air	140,000	105,000			342	36.9
23	Cr Mo Steel	.51	1.37			.48		1.11	.50		a	Quenched and Drawn	1725	90	Air	1000	180	Air	200,000	170,000			528	11.3
24	Cr Mo Steel	.51	1.37			.48		1.11	.50		a	Quenched and Drawn	1725	90	Oil	400	120	Air	250,000	225,000			640	4.7
25	Cr Mo Steel	.22	.55					5.00	.50		e	Quenched and Drawn	1700		Air	1250		Furnace	110,000	75,000	16.0	30.0	158	30.2
26	Cr Mo Steel	.19	.76			.39		5.57	.47		a	Quenched and Drawn	1850	90	Air	1200	120	Air	110,000	75,000	16.0	30.0	215	14.9
27	Cr V Steel	.65	.65					1.00		.19	e	Quenched and Drawn	1600		Air	1200		Furnace	·				293	18.7

a: Actual Analysis e: Estimated Analysis (1) Safe Harbor Runner Steel (2) Electric Furnace Cast Steel

TABLE III ROLLED LOW ALLOYED STEELS

No.	Alloy	Chemical Composition - Percentage of												Condition	Heat Treatments			Typical Physical Properties					Cavitation Loss in 16 hrs mm³ at 20°C.
		C	Mn	P	S	Si	Ni	Cr	Mo	V	W	Al			Temp. Heated Deg. F	Cooled in	Drawing Temp. Deg. F.	Tensile Strength Lbs./Sq. In.	Yield Point Lbs./Sq. In.	Elongation in 2 Inches %	Reduction of Area %	Brinell Hardness	
30	.30% Carbon Steel	.30	.80	.040*	.040*								e	As Received				60,000				145	135.0
31	2% Nickel Steel	19	.60	018	.024		2.16						a	Hot Rolled				75,070	49,230	31.0	62.0	142	44.5
32	5% Nickel Steel	.12	.45	.25			5.00						a	Hot Rolled				104,000	79,000	29.0	70.0	191	25.0
33	Ni Cr Steel	.26	.24	.016	.028	.060	3.23	1.37					a	As Received				121,000	106,000	25.0	63.5	248	26.1
34	Ni Nitriding Steel	18	.74	014	.026	.14	3.57	1.38	.25			1.17	a	Quenched and Drawn	1650	Oil	1230	120,000	107,000	23.0	65.0	238	23.2
35	Ni Mn Steel	.70	9.92	.050	.010	1.56	3.23	.17					a	As Received				145,000	47,500	65.0	43.0	233	126.0
36	Cr V W Tool Steel	.45	.25			.30		1.40		.25	1.60		e	Annealed				99,000	78,000	20.2	47.8	175	57.3
37	Cr V W Tool Steel	.45	.25			.30		1.40		.25	1.60		e	Tempered			1600	145,000	130,000	17.0	30.8	298	43.4
38	Cr V W Tool Steel	.45	.25			.30		1.40		.25	1.60		e	Tempered			1100	221,000	190,000	14.0	41.0	415	30.5

a: Actual Analysis e: Estimated Analysis * Maximum

TABLE IV FORGED LOW ALLOYED STEELS

No.	Alloy	Chemical Composition - Percentage of										Condition	Heat Treatments		Typical Physical Properties					Cavitation Loss in 16 hrs. mm³ at 20°C
		C	Mn	P	S	Si	Ni	Cr	Mo	V			Temp Heated Deg F	Cooled in	Tensile Strength Lbs./Sq. In.	Yield Point Lbs./Sq. In.	Elongation in 2 Inches %	Reduction of Area %	Brinell Hardness	
40	Wrought Iron	05	.007	115	080						a	As Forged			47,000	26,000	27.0	38.0	105	194.0
41	.22% Carbon Steel	.22	.52	.021	.026						a	Annealed	1500	Air	62,000	34,000	32.0	51.0	149	36.8
42	.49% Carbon Steel	.49	.66	.024	021						a	Drawn	1100	Air	89,000	56,000	26.0	47.0	163	24.7
43	2.5% Nickel Steel	.25	.91	.018	.028		2.68				a	Drawn	1200	Air	88,000	61,000	29.0	60.0	173	34.0
44	3.5% Nickel Steel	.42	.66	.031	.028		3.34				a	Drawn	1200	Air	98,000	59,000	25.0	52.0	163	42.1
45	5% Chromium Steel	.15	.50*	.04*	.04*	.50*		5.00			e	Drawn	1200	Air	105,000	78,000	25.0	70.0	202	39.1
46	Vanadium Steel	.48	.78	.018	.019					.19	a	Drawn	1200	Air	96,000	59,000	24.0	47.0	208	15.1
47	Ni Cr Steel	.50	.60	.032	.027		1.25	.81			a	Drawn	1200	Air	98,000	62,000	22.0	56.0	223	29.2
48	Ni Cr Steel	.40	.63	.019	.031	.188	1.32	.55			a	As Received			112,630	86,500	21.5	57.5	230	24.0
49	Ni Cr Steel	.29	.29	.032	.028	.072	3.53	1.74			a	As Received			112,100	98,400	25.0	65.9	222	24.2
50	Ni Cr Mo Steel	.37	.69	.019	.019		1.72	.71	.33		a	Drawn	1200	Air	101,100	73,000	22.0	55.0	295	11.5
51	Cr V Steel	.45	.76	.032	.030			1.03		.19	a	Drawn	1200	Air	96,000	60,000	22.0	50.0	262	23.5

a: Actual Analysis e: Estimated Analysis * Maximum

be illustrated when discussing the results obtained with the various materials.

B Pitting Characteristics of Materials Exposed to Cavitation

The results obtained with the test stand and the metallurgical data made available for the materials investigated are compiled in Tables 1 to 15. The materials are grouped according to the chemical composition and condition.

(a) Cast, Rolled, and Forged Materials. The irons listed in Table 1 can be divided into two groups according to the grain struc-

TABLE V. CAST STAINLESS AND HIGH ALLOYED STEELS

No	Alloy	C	Mn	P	S	Si	Ni	Cr	Mo	W	Fe	Cu	Co		Condition	Heat Treatments: Temp. Heated Deg F	Time Held Min.	Cooled in	Drawing Temp Deg F.	Time Held Min	Cooled in	Typical Physical Properties: Tensile Strength Lbs/Sq In.	Yield Point Lbs/Sq.in	Elongation in 2 Inches %	Reduction of Area %	Brinell Hardness	Cavitation Loss in 16hrs. mm³ at 20°C
60	Stainless 12% Cr Steel	.06	.43	.015	.028	.38	.17	12.88						a	Quenched and Drawn	1800	60	Air	1200	120	Air	82,000	60,000	25.5	62.8	167	41.0
61	Stainless 12% Cr Steel	.06	.43	.015	.028	.38	.17	12.88						a	Quenched and Drawn	1800	60	Air	1040	120	Air	99,000	77,500	22.0	50.5	206	24.6
62	Stainless 12% Cr Steel	.06	.43	.015	.028	.38	.17	12.88						a	Quenched and Drawn	1800	60	Air	900	120	Air	128,000	89,000	15.0	26.0	248	12.0
63	Stainless 13% Cr Steel	.10	.67			.77		13.37						a	Quenched and Drawn	1875	90	Air	1200	120	Air	82,000	52,000	22.4	46.3	210	19.2
64	Stainless 17% Cr Steel	.10•	.45	.035•	.035•	.50•		17.50						e	Ingot Cropping							85,000	40,000	7.0	7.0	201	67.0
65	Stainless 20% Cr Steel	.24	.40			.78		20.08						a	Annealed	1550	120	Furnace				100,000	75,000	7.5	8.5	190	10.6
66	Stainless 20% Cr Steel	.24	.40			.78		20.08						a	Quenched and Drawn	1875	90	Air	900	120	Air					503	9.7
67	Stainless 12% Cr Ni Steel	.08	.49	.016	.021	.48	1.53	12.44						a	Quenched and Drawn	1800	60	Air	1200	120	Air	107,250	83,000	18.7	51.3	232	10.3
68	Stainless 12% Cr Ni Steel	.08	.49	.016	.021	.48	1.53	12.44						a	Quenched and Drawn	1800	60	Air	1040	120	Air	126,250	107,500	15.5	48.7	281	6.3
69	Stainless 12% Cr Ni Steel	.08	.49	.016	.021	.48	1.53	12.44						a	Quenched and Drawn	1800	60	Air	900	120	Air	164,000	125,000	12.2	29.7	363	5.0
70	Stainless 15% Cr Ni Steel	.05					.50	15.20						a	As Cast (Sand Mold)											220	113.0
71	Stainless 15% Cr Ni Steel	.07					.15	15.50						a	As Cast (Cast Iron Mold)											266	48.9
72	Stainless 14% Cr Ni Steel	.06	.39	.016	.021	.33	.98	14.72						a	As Cast (Sand Mold)											238	85.5
73	Stainless 14% Cr 1% Ni Steel	.05	.32	.016	.021	.35	1.14	14.48						a	As Cast (Sand Mold)											302	32.0
74	Stainless 14% Cr 2% Ni Steel	.05	.36	.018	.019	.31	2.02	14.30						a	As Cast (Sand Mold)											321	12.9
75	Stainless 14% Cr 3% Ni Steel	.07	.35	.016	.015	.40	3.36	14.30						a	As Cast (Sand Mold)											352	9.8
76	Stainless 13% Cr Mo Steel	.10	.47	.014	.027	.33	.12	12.88	.58					a	Quenched and Drawn	1800	60	Air	1200	120	Air	106,500	86,000	18.5	43.7	223	19.6
77	Stainless 13% Cr Mo Steel	.10	.47	.014	.027	.33	.12	12.88	.58					a	Quenched and Drawn	1800	60	Air	1040	120	Air	123,750	97,250	12.7	27.9	275	9.5
78	Stainless 13% Cr Mo Steel	.10	.47	.014	.027	.33	.12	12.88	.58					a	Quenched and Drawn	1800	60	Air	900	120	Air	149,500	111,000	9.7	12.4	316	7.7
79	Stainless 14% Cr Si Ni Mo Steel	.46	.41			1.53	34.58	14.52	.53					a	Normalized and Quenched	1875	90	Water				77,000	26,000	5.5	5.0	182	18.1
80	Stainless 18-8 Cr Ni Steel	.10	.40			.60	8.00	18.00						e	As Cast											135	11.8
81	Stainless 18-8 Cr Ni Steel	.08					8.25	18.50						e	Ingot Cropping							75,000	30,000	50.0	45.0	145	8.8
82	Stainless 18-8 Cr Ni Steel	.07	.72			3.43	10.06	20.61						a	Quenched	2050		Water				72,000	30,000	60.0	55.0	152	8.0
83	3.5% Si Monel	.03	1.00		.010	3.50	66.00				1.50	28.00		a	As Cast											217	11.4
84	Si Ni Cr Cu Steel	.65	1.00			2.36	18.86	2.63				7.00		a	As Cast							77,500	54,500	11.0	17.0	166	14.9
85	Stellite	1.00						30.00		4.00			65.00	e	As Received							66,000				382	2.1

a: Actual Analysis e: Estimated Analysis • Maximum

TABLE VI. ROLLED STAINLESS AND HIGH ALLOYED STEELS

No.	Alloy	C	Mn	P	S	Si	Ni	Cr	Mo	W	Cu	Al	Co		Condition	Heat Treatments: Temp Heated Deg F	Time Held Min	Cooled in	Typical Physical Properties: Tensile Strength Lbs/Sq In	Yield Point Lbs/Sq In	Elongation in 2 Inches %	Reduction of Area %	Brinell Hardness	Cavitation Loss in 16 hrs mm³ at 20°C
90	Stainless 12% Cr Steel	.12•	.45	.025•	.025•	.40		12.25						e	Annealed	1500		Furnace	73,000	40,000	32.0	70.0	142	46.7
91	Stainless 12% Cr Steel	.12•	.45	.025•	.025•	.40		12.25						e	Tempered	1150		Air	105,000	85,000	23.5	71.7	213	20.3
92	Stainless 12% Cr Steel	.12•	.45	.025•	.025•	.40		12.25						e	Tempered	1000		Air	145,000	133,000	19.0	64.0	285	8.3
93	Stainless 12% Cr Steel	.12•	.45	.025•	.025•	.40		12.25						e	Quenched	1800		Oil	180,000	162,000	15.0	51.0	401	3.5
94	Stainless 12% Cr Steel	.12	.48	.010	.014	.33		12.36						a	Annealed	1450		Furnace	87,000	60,000	31.2	73.9	178	88.9
95	Stainless 12% Cr Steel	.10•	.45	.035•	.035•	.50•		12.50						e	Tempered				110,000	80,000	25.0	71.0	248	15.6
96	Stainless 13% Cr Steel	.36	.42	.019	.022			13.23						a	Fully Annealed	1600	360	Furnace					161	80.9
97	Stainless 13% Cr Steel	.12•	.60•	.15•	.40•	.50•		13.50						e	As Received								157	72.3
98	Stainless 17% Cr Steel	.10	.32	.035•	.035•	.49	.20	17.59						e	Annealed	1400		Air	84,000	53,000	33.0	64.0	167	103.0
99	Stainless 18% Cr Steel	.10	.34	.029	.021	.46		18.12						a	Hot Rolled				91,000	50,000			207	16.6
100	Stainless 12% Cr 1% Ni Steel	.09	.48	.028	.019	.38	1.18	12.46						a	Hot Rolled and Annealed	1425	180	Furnace	175,000	135,000			159	73.0
101	Stainless 12% Cr Ni Mo Steel	.11	.51			.34	.16	12.23	.35					a	Annealed	1550	90	Furnace	80,000	45,000	32.0	73.0	156	42.7
102	Stainless 12% Cr Ni Mo Steel	.11	.51			.34	.16	12.23	.35					a	Tempered	1200	240	Air	120,000	90,000	22.0	70.0	223	15.1
103	Stainless 12% Cr Ni Mo Steel	.11	.51			.34	.16	12.23	.35					a	Hot Rolled				175,000	125,000	20.0	58.0	375	4.6
104	Stainless 12% Cr Ni Mo Steel	.11	.51			.34	.16	12.23	.35					a	Tempered	1800	30	Air	185,000	130,000	18.0	55.0	401	4.5
105	Stainless 12% Cr 1% Ni Mo Steel	.05	.95			.50	1.00	11.65	.49					a	Annealed				100,000	75,000			200	33.2
106	Stainless 12% Cr 1% Ni Mo Steel	.05	.95			.50	1.00	11.65	.49					a	Tempered	1800	30	Air	180,000	135,000	8.0	30.0	341	7.1
107	Stainless 13% Cr Ni Mo Cu Steel	.06	.85			.21	.82	13.48	.57		.77	.11		a	Tempered	1800	30	Air	160,000	120,000	12.0	40.0	316	9.7
108	Stainless 18-8 Cr Ni Steel	.05	.59	.025•	.025•	.41	8.96	18.69						a	Drawn and Quenched	1950		Water	95,000	40,000	60.0	70.0	144	14.6
109	Stainless 18-8 Cr Ni Steel	.07	.52			.39	9.44	19.76						a	Drawn and Quenched	2300	60	Water	90,000	30,000	70.0	65.0	128	26.7
110	Stainless 18-8 Cr Ni Steel	.07	.52			.39	9.44	19.76						a	Drawn and Quenched	1800	60	Water	100,000	35,000	65.0	60.0	151	14.9
111	Stainless 18-8 Cr Ni Steel	.08•	.50•	.025•	.025•	.50•	8.50	18.00						e	Annealed	1900		Water	93,000	30,500	58.0	67.0	153	13.9
112	Stainless 18-8 Cr Ni Steel	.14	.17			.34	8.06	17.65			.06			a	As Received				122,300	41,000	46.0	37.2	182	3.7
113	Stainless 24-12 Cr Ni Steel	.20•	1.25•	.025•	.025•	.50•	11.50	23.50						e	Annealed	2100		Water	96,000	46,000	62.0	69.0	139	8.6
114	Stainless 26-13 Cr Ni Steel	.06	.53	.014	.018	.30	13.32	26.20						a	Hot Rolled								161	4.1
115	20% Ni 8% Cr Steel	.43	.19			1.13	20.71	7.92						a	Hot Rolled				111,500	55,000	48.0	59.9	159	9.3
116	97% Ni Steel	.27	.75		.01	.03	97.73				.21			a	Hot Rolled								281	8.6
117	Stellite	1.10△						30.00		15.50			50.00	e	As Received								578	2.8
118	Stellite	1.10△						30.00		8.00			60.00	e	As Received								437	1.7
119	Stellite	1.00						30.00		4.00			65.00	e	As Received								486	0.9

a: Actual Analysis e: Estimated Analysis • Maximum △ Minimum

ture. Specimens nos. 1 to 4 have basically a ferritic type of grain structure while specimens nos. 5 to 7 show an austenitic matrix. It can readily be seen that for each individual group the effect of the hardness is clearly indicated as the cavitation loss decreases consistently with increasing hardness. However, comparing the losses of both groups with each other the influence of hardness appears to be overshadowed by a characteristic originating in the grain structure. An austenitic matrix, in which various constituents form a solid solution, appears definitely superior to one of the ferritic type, consisting of separate complexes of elements or combinations of elements. The reason for this phenomenon lies in the excellent cold working properties of the austenite.

Comparing the results obtained on irons with those on plain and alloyed steels in Table 2, it becomes evident that the losses of the former group were comparatively large. The reason may be attributed to the free carbon content of the irons, present in the form of flakes. Keeping in mind the nature of the punish-

TABLE VII FORGED AND COLD DRAWN HIGH ALLOYED STEELS

No.	Alloy	C	Mn	P	S	Si	Ni	Cr	Fe	Cu		Condition	Tensile Strength Lbs. Sq. In.	Yield Point Lbs. Sq. In.	Elongation in 2 Inches %	Reduction of Area %	Brinell Hardness	Cavitation Loss in 16 hrs. mm³ at 20°C
		Chemical Composition - Percentage of											Typical Physical Properties					
120	Stainless 14% Cr Steel	.08	.34	.014	.023			14.%			a	Forged and Oil Quenched	70,000	46,000	32.0	[illegible]	163	167.3
121	Stainless 17% Cr Steel	.08	.34	.014	.023			17.57			a	Forged and Oil Quenched	74,000	45,000	35.0	63.0	150	14.5
122	36% Ni 11% Cr Steel	.35	.40			.60	36.00	11.00			e	As Forged					160	13.9
123	35% Ni Steel	.25	1.00			.20	35.00				e	As Forged					112	74.0
124	Monel	.17	1.11		.009	.03	67.43		1.43	29.80	a	Cold Drawn	95,000	70,000	22.0		208	26.6
125	Inconel	.06	.96		0.0	.36	80.23	12.69	5.8	.06	a	Cold Drawn	145,000	134,000	0.0	55.0	262	27.0

a Actual Analysis e Estimated Analysis

TABLE VIII. CAST BRASSES, BRONZES AND NON-FERROUS ALLOYS

No.	Alloy	Cu	Sn	Zn	Mn	Si	Ni	Fe	Pb	Al	Mg		Condition	Tensile Strength Lbs. Sq. In.	Yield Point Lbs. Sq. In.	Elongation in 2 Inches %	Reduction of Area %	Brinell Hardness	Cavitation Loss in 16 hrs. mm³ at 20°C
		Chemical Composition - Percentage of												Typical Physical Properties					
130	Everdur	94.00			1.00	4.50						e	As Cast	50,000	25,000	22.0		82	258.0
131	Phosphor Deoxidized Cu-Sn Alloy	90.00	10.00									e	As Cast	40,000	18,000	12.0		54	57.0
132	Aluminum Bronze	89.00						1.00		10.00		e	As Cast	70,000	35,000	20.0		107	41.6
133	Gun Metal	87.50	8.00	4.00			.50					e	As Cast	40,000	20,000	25.0		61	391.0
134	P.M.G. Metal	90.43		.81	.03	3.67		.67				a	As Cast	50,000	25,000	18.0		111	36.8
135	Hy-ten-sl Bronze No. 4	68.00		22.00	4.00			3.00		3.00		e	As Cast	85,000	40,000	25.0	25.0	165	43.3
136	Hy-ten-sl Bronze No. 3	67.00		22.00	4.00			3.00		4.00		e	As Cast	90,000	45,000	20.0	20.0	171	28.7
137	Hy-ten-sl Bronze No. 2	66.00		22.00	4.00			3.00		5.00		e	As Cast	100,000	55,000	15.0	15.0	172	20.9
138	Hy-ten-sl Bronze No. 2	66.00		22.00	4.00			3.00		5.00		e	Cast and Slow Cooled					[illegible]	55.0
139	Hy-ten-sl Bronze No. 2	66.00		22.00	4.00			3.00		5.00		e	Chilled in Cast Iron Mold					2.7	16.0
140	Hy-ten-sl Bronze No. 1	65.00		22.00	4.00			3.00		6.00		e	As Cast	[illegible]	65,000	12.0	12.0	204	22.0
141	Super Strength Bronze	64.00		24.00	3.00			2.00		5.00		e	As Cast	90,000	45,000	25.0	20.0	208	66.6
142	Super Strength Bronze	64.00		24.00	3.00			2.00		5.00		e	Chilled in Cast Iron Mold					226	25.9
143	Manganese Bronze	58.00		40.00	2.00							e	As Cast	65,000	33,000	25.0		114	252.0
144	Manganese Bronze	57.06		40.64	.75			1.26		.59		a	As Cast	66,000		42.0	93.0	96	187.0
145	Manganese Bronze	55.00*	1.50*	38.00*	3.50*			2.00*	.20*	1.50*		e	As Cast	65,000	30,000	22.0		129	135.0
146	Turbine Metal	56.00		36.00	2.00		3.00	1.00		1.00		e	As Cast	80,000	40,000	20.0		166	80.2
147	Turbadium Bronze	50.00		44.00	1.75		2.00	1.00				e	As Cast	70,000	35,000	17.0		154	101.0
148	Turbine Metal	50.00		46.00*			2.50*					e	As Cast	75,000	35,000	25.0		153	158.0
149	Aluminum Alloy No. 214	.04				.14		.22		97.46	2.14	a	As Cast	25,000	12,000	9.0		49	1810.0
150	Aluminum Alloy No. 356-T6	.08				6.35		.27		93.49	.31	a	As Cast	32,000	22,000	4.0		74	3420.0

a: Actual Analysis e: Estimated Analysis *Maximum *Minimum

TABLE IX ROLLED AND EXTRUDED BRONZES AND NON-FERROUS ALLOYS

No.	Alloy	Cu	Zn	Mn	Si	Cr	Fe	Al	Mg		Condition	Tensile Strength Lbs. Sq. In.	Yield Point Lbs. Sq. In.	Elongation in 2 Inches %	Reduction of Area %	Brinell Hardness	Cavitation Loss in 16 hrs. mm³ at 20°C
		Chemical Composition - Percentage of										Typical Physical Properties					
160	P.M.G. Metal	78.00*	2.00							e	As Rolled	55,000	60,000	30.0		123	56.4
161	Hy-ten-sl Bronze No. 2	66.00	22.00	4.00			3.00	5.00		e	As Rolled	105,000	60,000	12.0	12.0	217	9.6
162	Super Strength Bronze	64.00	24.00	3.00			2.00	5.00		e	As Rolled	93,000	50,000	20.0	20.0	204	18.5
163	Aluminum Alloy No. 53S-W				.72	.25	.19	97.66	1.18	a	As Rolled	33,000	20,000	30.0		45	7000.0
164	Aluminum Alloy No. 17ST	4.00		.50				95.00	.50	a	Extruded	58,000	35,000	20.0		109	546.0

a: Actual Analysis e: Estimated Analysis *Minimum

TABLE X SURFACE TREATED MATERIALS

No	Alloy	C	Mn	P	S	Si	Ni	Cr	Mo	V	Fe	Al	Mg		Condition	Surface Treatments	Brinell Hardness from Rockwell	Brinell Hardness from Pendulum	Cavitation Loss in 16 hrs. mm³ at 20°C
		Chemical Composition - Percentage of																	
170	.20% Carbon Steel	.20	.45	.045*	.055*									e	Cast	Chapmanized	388		39.1
171	Nitralloy	.34	.53	.017	.020		.25		.20			.95		a	Forged	Nitrided	735		109.0
172	Cr V Nitralloy	.28	.55	.025	.028			1.50		.53				a	Forged	Nitrided	940		280.0
173	Aluminum Alloy No. 52S-H					.10		.26			.17	97.02	2.45	a	Rolled	Alumilite Finish	80		4200.0
174	Stainless Clad Carbon Steel	.10					8.00	18.00						e	Rolled	Clad ⅛ in. Rolled with Steel		131	11.2
175	.33% Carbon Steel	.33	.71	.032	.030	.33								a	Cast	Cloud Burst Hardened No. 2		284	43.[illegible]
176	.33% Carbon Steel	.33	.71	.032	.030	.33								a	Cast	Cloud Burst Hardened No. 3		216	51.9
177	Stainless 18-8 Cr Ni Steel	.05	.59	.025	.025	.41	8.96	18.69						a	Rolled	Cloud Burst Hardened No. 1		405	2.5
178	Stainless 18-8 Cr Ni Steel	.05	.59	.025	.025	.41	8.96	18.69						a	Rolled	Cloud Burst Hardened No. 3		405	1.4
179	Stainless 18-8 Cr Ni Steel	.05	.59	.025	.025	.41	8.96	18.69						a	Rolled	Cloud Burst Hardened No. 4		376	2.2

*Maximum a: Actual Analysis e: Estimated Analysis

Notes. No. 175 & 176 same as No. 10, Table II. (Cavitation Loss = 62.4 mm³)
No. 177-179 same as No. 108, Table VI. (Cavitation Loss = 14.6 mm³)

Cloud Burst Treatment ⅛" ϕ Steel Balls 40,000 blows per minute per sq in.
- No. 1: 30 minutes - .50 meter fall
- No. 2: 50 minutes - .50 meter fall
- No. 3: 30 minutes - .50 meter fall plus 30 minutes - 1.0 meter fall
- No. 4: 30 minutes - .50 meter fall plus 30 minutes - 1.0 meter fall plus 30 minutes 1.5 meter fall

ment as best defined by implosions in rapid succession, high stress concentrations are likely to occur in the vicinity of flake tips. It is obvious that the number and the size of these flakes may influence the pitting resistance. This may best be illustrated by specimen no. 5, Table 1, showing an unusually high loss in comparison to specimens nos. 6 and 7 in spite of its austenitic matrix. Ordinarily, fine distribution of the free carbon content may be observed in these nickel-copper cast irons, that is, a large number of flakes of small size. The photomicrographic analysis disclosed that this specimen contained fewer flakes of

Table XI. Electric Arc Welded Low Alloyed Steels

No.	Alloy	Chemical Composition - Percentage of									Data on Coating of Electrodes and Characteristics of Deposit					Cavitation Loss in 16 hrs. mm³ at 20°C
		C	Mn	P	S	Si	Ni	Cr	Mo		Origin	Type of Deposit	Base Metal	No. of Layers	Brinell Hardness	
180	.07% Carbon Steel	.07	.33	.017	.03	.01				a	A	Normal Deposit of all Constituents	Wrought Iron	2	156	73.6
181	.08% Carbon Steel	.08	.35	.035*	035*	.06				e	B	Normal Deposit of all Constituents	Wrought Iron	2	147	66.9
182	.13% Carbon Steel	.13	.30	.015	03	07				a	C	Normal Deposit of all Constituents	Wrought Iron	2	145	76.3
183	Mn Steel	.11	.39	.017	.02			.02		a	C	7-8% Mn in Deposit from Coating	Wrought Iron	2	156	39.2
184	Mo Steel	.12	.60	.035*	.035*	.08			.50	e	B	Normal Deposit of all Constituents	Wrought Iron	2	158	86.9
185	Ni Mo Steel	.08	.60	.035*	.035*	.08	2.30		.30	e	B	Normal Deposit of all Constituents	Wrought Iron	2	180	68.0
186	Cr Mo Steel	1.25	.50	.04*	.04*	.50*		5.00	1.50	e	D	Normal Deposit of all Constituents	Wrought Iron	2	258	18.6

a: Actual Analysis e: Estimated Analysis * Maximum

Table XII Electric Arc Welded Stainless Chromium Steels

No.	Alloy	Chemical Composition of Wire - Percentage of										Data on Coating of Electrodes and Characteristics of Deposit					Cavitation Loss in 16 hrs. mm³ at 20°C
		C	Mn	P	S	Si	Ni	Cr	Mo	Cu		Origin	Type of Deposit	Base Metal	No. of Layers	Brinell Hardness	
190	Stainless 12% Cr Ni Steel	.06	.75	.023	.022	.44	.59	12.48			a	C	Normal Deposit of all Constituents	Wrought Iron	1	287	27.6
191	Stainless 12% Cr Ni Steel	.06	.75	.023	.022	.44	.59	12.48			a	C	Normal Deposit of all Constituents	Wrought Iron	2	310	8.4
192	Stainless 12% Cr Ni Steel	.06	.75	.023	022	.44	.59	12.48			a	C	Normal Deposit of all Constituents	Boiler Plate	2	319	8.1
193	Stainless 12% Cr Ni Steel	.06	.75	.023	.022	.44	.59	12.48			a	C	Normal Deposit of all Constituents	Welded .15% C Steel	1	277	55.0
194	Stainless 12% Cr Ni Steel	.06	.75	.023	.022	.44	.59	12.48			a	C	Normal Deposit of all Constituents	Welded Stainless 18-8	1	291	3.8
195	Stainless 13% Cr Ni Steel	.06	.38	.013	.014	.74	.44	13.32			a	E	Normal Deposit of all Constituents	Wrought Iron	2	346	9.6
196	Stainless 13% Cr Ni Steel	.07	.55	.033	.01	.61	.32	13.57			a	D	Normal Deposit of all Constituents	Wrought Iron	2	278	6.3
197	Stainless 13% Cr Ni Mo Cu Steel	.06	.87	.035*	.035*	.90	.70	13.38	.58	.66	a	C	Normal Deposit of all Constituents	Wrought Iron	2	295	16.3
198	Stainless 13% Cr Ni Mo Cu Steel	.06	.87	.035*	.035*	.90	.70	13.38	.58	.66	a	C	Normal Deposit of all Constituents	Stainless Cr Steel	1	326	7.3
199	Stainless 15% Cr Ni Steel	.06	.39	.015	.03	.25	.10	15.53			a	D	Normal Deposit of all Constituents	Wrought Iron	2	258	7.1
200	Stainless 15% Cr Ni Steel	.06	.36	.022	.02	.36	.09	15.73			a	C	Normal Deposit of all Constituents	Wrought Iron	2	349	8.8
201	Stainless 15% Cr Ni Steel	.06	.36	.022	.02	.36	.09	15.73			a	C	1.25-1.50% Mn Deposit from Coating	Wrought Iron	2	366	8.8
202	Stainless 16% Cr Ni Steel	.16	.15	.03*	.03*	.32	.78	16.45			a	C	Normal Deposit of all Constituents	Wrought Iron	2	293	5.3
203	Stainless 16% Cr Ni Steel	.05	.33	.015	.01	.035	1.09	16.81			a	D	Normal Deposit of all Constituents	Wrought Iron	2	366	8.9
204	Stainless 17% Cr Ni Steel	.06	.39	.04	.01	.35	1.43	17.71			a	D	Normal Deposit of all Constituents	Wrought Iron	2	390	7.8
205	Stainless 18% Cr Ni Steel	.13	.48	.013	.013		.21	18.21			a	D	Normal Deposit of all Constituents	Wrought Iron	2	350	6.9
206	Stainless 18% Cr Ni Steel	.13	.48	.013	.013		.21	18.21			a	D	Some Softener Removed from Coating	Wrought Iron	2	315	14.6
207	Stainless 18% Cr Ni Steel	.13	.48	.013	.013		.21	18.21			a	D	More Softener Removed from Coating	Wrought Iron	2	309	6.8
208	Stainless 18% Cr Ni Steel	.13	.48	.013	.013		.21	18.21			a	D	Most Softener Removed from Coating	Wrought Iron	2	304	9.1
209	Stainless 19% Cr Steel	.09	.47	.03*	.03*	.43		19.03			a	C	Normal Deposit of all Constituents	Wrought Iron	2	238	56.5
210	Stainless 19% Cr Steel	.09	.47	.03*	.03*	.43		19.03			a	C	1.25-1.50% Mn Deposit from Coating	Wrought Iron	2	285	22.7
211	Stainless 19% Cr Steel	.07	.65	.010	.01	.45	.09	19.24			a	D	Normal Deposit of all Constituents	Wrought Iron	2	222	17.7
212	Stainless 21% Cr Cu Steel	.28			.021	.36		21.54		1.02	a	D	Normal Deposit of all Constituents	Wrought Iron	2	374	4.0
213	Stainless 28% Cr Steel	.10*	.50*	.03*	.03*	.50*		28.00			e	A	Normal Deposit of all Constituents	Wrought Iron	2	262	11.1
214	Stainless 28% Cr Ni Mo Steel	.09			.01	.46	4.24	27.92	1.49		a	D	Normal Deposit of all Constituents	Wrought Iron	2	256	3.5

a: Actual Analysis e: Estimated Analysis * Maximum

Table XIII. Electric Arc Welded Stainless Chromium Nickel Steels

No.	Alloy	Chemical Composition of Wire - Percentage of											Data on Coating of Electrodes and Characteristics of Deposit					Cavitation Loss in 16 hrs. mm³ at 20°C.
		C	Mn	P	S	Si	Ni	Cr	Mo	Ti	Cb		Origin	Type of Deposit	Base Metal	No of Layers	Brinell Hardness	
220	Stainless 17-9 Cr Ni Steel	.09	.53	.010	.016		9.86	17.49				a	D	Normal Deposit of all Constituents	Wrought Iron	2	178	38.7
221	Stainless 17-9 Cr Ni Steel	.09	.53	.010	.016		9.86	17.49				a	D	Normal Deposit of all Constituents	Wrought Iron	2	207	26.8
222	Stainless 17-9 Cr Ni Steel	12	.60*	.03*	03*	.75*	8.84	17.78				a	C	Normal Deposit of all Constituents	Wrought Iron	2	206	23.4
223	Stainless 18-8 Cr Ni Steel	07	50	.035*	.035*	.50	8.75	18.25				e	D	Normal Deposit of all Constituents	Wrought Iron	2	218	24.6
224	Stainless 18-8 Cr Ni Steel	07	50	035*	.035*	.50	8.75	18.25				e	D	Normal Deposit of all Constituents	Boiler Plate	2	230	8.2
225	Stainless 19-8 Cr Ni Steel	.05	36	021	013	.39	8.30	19.45				a	C	Normal Deposit of all Constituents	Wrought Iron	2	204	13.8
226	Stainless 19-8 Cr Ni Steel	05	59	.023	02	72	8.64	19.24				a	C	Normal Deposit of all Constituents	Wrought Iron	2	222	8.5
227	Stainless 20-9 Cr Ni Steel	.05	.58	.03*	.03*	.47	9.71	20.55				a	C	Normal Deposit of all Constituents	Wrought Iron	2	188	37.1
228	Stainless 20-9 Cr Ni Steel	.05	.58	.03*	03*	.47	9.71	20.55				a	C	Normal Deposit of all Constituents	Boiler Plate	2	192	98
229	Stainless 20-7 Cr Ni Steel	.06	74	.022	.026	.50*	7.68	20.66				a	B	Normal Deposit of all Constituents	Wrought Iron	2	192	31.9
230	Stainless 21-7 Cr Ni Steel	08	.79	.008	006	.50*	7.86	21.88				a	F	Normal Deposit of all Constituents	Wrought Iron	2	265	17.6
231	Stainless 29-9 Cr Ni Steel	.10					9.00	29.00				e	D	Normal Deposit of all Constituents	Wrought Iron	2	260	16.5
232	Stainless 20-9 Cr Ni Mn Steel	.05	.56	03	.03	.47	9.71	20.55				a	C	1.25-1.50% Mn Deposit from Coating	Wrought Iron	2	191	25.8
233	Stainless 21-10 Cr Ni Mn Steel	06	1.62	.017	.01	.80	10.71	21.45				a	D	Normal Deposit of all Constituents	Wrought Iron	2	195	28.9
234	Stainless 18-9 Cr Ni Si Steel	.06	.57	.017	.015	2.30	9.43	17.98				a	C	Normal Deposit of all Constituents	Wrought Iron	2	216	12.1
235	Stainless 18-25 Cr Ni Si Steel	.05	.52	.017	.01	2.88	25.31	18.39				a	C	Normal Deposit of all Constituents	Wrought Iron	2	162	24.6
236	Stainless 18-9 Cr Ni Mo Steel	.07*	.40*	.03*	.03*	.50*	9.00	18.50	3.00			e	B	Normal Deposit of all Constituents	Wrought Iron	2	227	16.8
237	Stainless 17-10 Cr Ni Mo Steel	.06	1.38	.016	.006	.43	10.62	17.67	2.40			a	D	Normal Deposit of all Constituents	Wrought Iron	2	215	25.4
238	Stainless 19-9 Cr Ni Ti Steel	04	.56	.022	017	.42	9.80	19.86		.25		a	C	Normal Deposit of all Constituents	Wrought Iron	2	198	14.3
239	Stainless 17-11 Cr Ni Cb Steel	.05	.32	.004	.009	.41	11.32	17.25			.84	a	D	Normal Deposit of all Constituents	Wrought Iron	2	233	13.7
240	Stainless 20-9 Cr Ni Cb Steel	07	.68	024	017	43	9.42	20.42			65	a	D	Normal Deposit of all Constituents	Wrought Iron	2	193	16.2
241	Stainless 17-7 Cr Ni Steel	11	69	.025*	.025*	37	7.55	17.44				a	C	Normal Deposit of all Constituents	Wrought Iron	2	373	1.3

a: Actual Analysis e: Estimated Analysis * Maximum

unusually large proportions which facilitated separation along the boundaries of the flakes.

In view of the fact that, in the iron group, the strain-hardening effect is superimposed by the influence of the carbon distribution, it may be well to check this phenomenon on cast and rolled stainless steels. For instance in Table 5, specimens nos. 64 and 81 show a very large difference in pitting resistance. Although the original hardness and the yield point of the austenitic, stainless, 18-8 chromium-nickel steel were lower than that of the stainless 17 per cent chromium steel, the pitting resistance of

TABLE XIV ACETYLENE WELDED MATERIALS

No	Alloy	Chemical Composition - Percentage of C	Mn	P	Si	Cr	W	Sn	Cu	Zn	Co		Data on Deposit: Base Metal	No. of Layers	Brinell Hardness	Cavitation Loss in 16 hrs. mm³ at 20°C
250	Tobin Bronze							.75	60.00	39.25		e	Wrought Iron	2	81	386.0
251	Everdur		1.10		3.50				95.40			e	Wrought Iron	2	58	599.0
252	Phosphor Copper Bronze			7.50					92.50			e	Wrought Iron	2	137	1370.0
253	DX-Bronze												Wrought Iron	2	88	540.0
254	Stellite "G"												Wrought Iron	2	550	10.8
255	Stellite	1.00				30.00	4.00				65.00	e	Wrought Iron	2	346	6.3
256	Stellite	1.10^				30.00	9.00				60.00	e	Wrought Iron	2	351	3.4
257	Stellite	1.10^				30.00	15.50				52.00	e	Wrought Iron	2	394	3.9
258	High Carbon Cr Mn Steel	1.10^	3.50			15.00•						e	Wrought Iron	2	258	12.4
259	Mn Bronze												Wrought Iron	2	115	300.0

e Estimated Analysis • Maximum ^ Minimum

TABLE XV SPRAYED MATERIALS

No	Alloy	Chemical Composition of Wire - Percentage of C	Mn	P	S	Si	Ni	Cr	Fe	Sn	Cu	Zn		Data on Deposit: Depth of Deposit-In.	Brinell Hardness	Cavitation Loss in 16 hrs. mm³ at 20°C
260	.10% Carbon Steel	.10	.50	.06•	.05•	.02•							e	.25	181	561.0
261	.85% Carbon Steel	.85	.44	.025	.032	.17							a	.25	266	350.0
262	Stainless 13% Cr Steel	.43•	.43•	.015•	.016•	.32•		13.50•					e	.25	263	185.0
263	Stainless 18-8 Cr Ni Steel	.06•	.62•	.022•	.022•	.37•	9.25•	21.20•					e	.25	131	207.0
264	Stainless 15% Cr 62% Ni Steel	.20	.20			.35•	62.00	15.00					e	.25	172	275.0
265	Monel	.20	1.00			.10•	68.00		1.50		29.00		e	.25	115	477.0
266	Tobin Bronze									.75	60.00	39.25	e	.25	79	2090.0

a: Actual Analysis e: Estimated Analysis • Maximum

showing cast nonferrous alloys, it may be observed that specimens nos. 135 and 146 show decidedly different losses in spite of the fact that the Brinell hardness and the yield point are of the same magnitude. At the same time Rockwell-hardness tests in the zone of attack showed only minor differences in the susceptibility to strain hardening for the two alloys. The only real difference was disclosed by the photomicrographic analysis which showed the grain size of specimen no. 135 to be appreciably smaller than that of no. 146. This seems to indicate that the resistance to cavitation increases with decreasing grain size.

The above characteristic is not surprising as the failure in most cases was found to be transcrystalline. From the metallographic studies, it was apparent that the progress of fatigue cracks was retarded temporarily by the grain boundaries. The more grain boundaries encountered, the more difficult it is for a crack to make headway. This phenomenon may be true, not only with respect to the fatigue cracks, but also for those separations taking place in the zone of plastic deformation after the capacity to yield has been exhausted.

From the data given in Tables 2, 5, and 6, it is the former alloy is far superior. All other austenitic stainless steels listed in Tables 5 and 6, show the same tendency whether they are of the 18-8, 24-12, or 26-13 chromium-nickel variety.

There can be but little doubt that strain hardening is of far-reaching importance, nevertheless its beneficial effect may not necessarily overshadow the influence of the original hardness. This is substantiated by a comparison of the losses and the physicals of specimens nos. 108 to 112, inclusive, in Table 6.

In addition to the influence of surface hardening noticeable not only on austenitic materials referred to above but also on many other alloys not particularly susceptible thereto the grain size appears to be of far-reaching importance. From Table 8

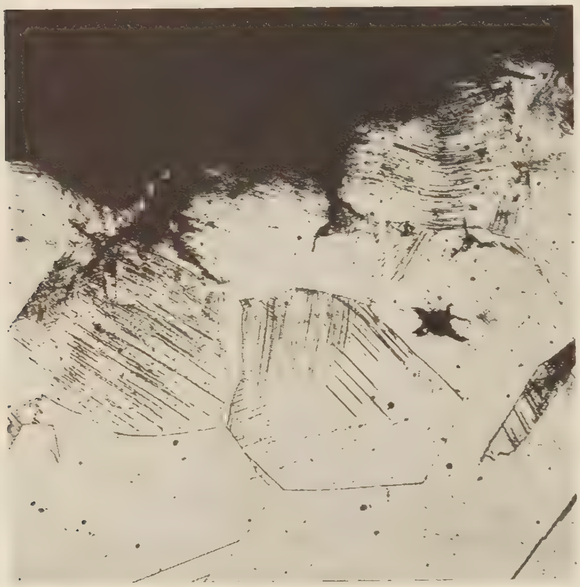


FIG. 8 COARSE GRAINED, STAINLESS, 18–8 CHROMIUM-NICKEL STEEL. NOTE SLIP BANDS AND FATIGUE CRACKS (Specimen No. 109, Table 6. ×100.)

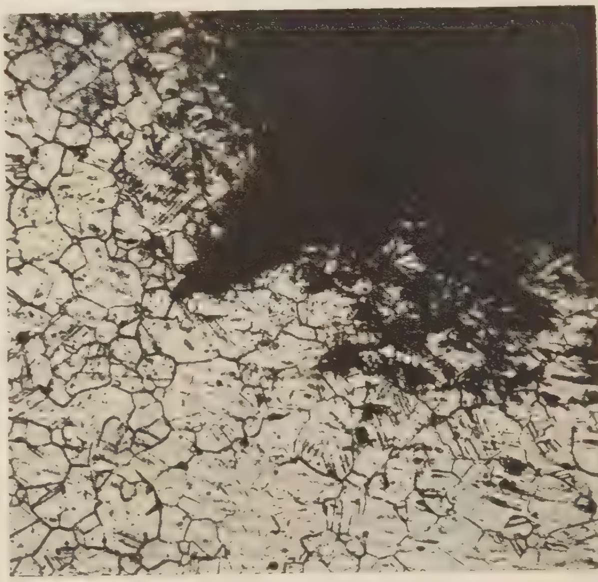


FIG. 9 FINE GRAINED, STAINLESS, 18–8 CHROMIUM-NICKEL STEEL (Specimen No. 110, Table 6. ×200.)

also evident that heat-treatment has a decided effect. This is to be expected as treatment affects both the physicals and the grain size. Its effect can best be shown by keeping the chemical composition constant and varying the treatment. What may be accomplished even with low-alloy steels is indicated by the high resistances obtained with the chromium-molybdenum steel series, Table 2, specimens nos. 22 to 24. A somewhat larger range of losses was observed by the treated, rolled, stainless, 12 per cent chromium-steel specimens nos. 90 to 93 in Table 6. In the same table another typical example is the rolled, stainless 18-8 chromium-nickel specimens nos. 109 and 110. Figs. 8 and 9.

Generally speaking, the results indicated that rolling and forging are advantageous, and often superior to casting, as higher

physicals can be obtained. Rolling and forging may, however, be detrimental in cases where a well-defined stratification is produced which is conducive to separation along parallel grain layers. Photomicrographic analysis showed that a weakness from this source becomes particularly apparent where, due to the processing and heat-treatment, a laminated structure is obtained consisting of large grains. This phenomenon was found to be of minor or no importance with greatly refined grain structures where more interlocking is provided.

Not only are differences to be expected in specimens produced by the various manufacturing procedures such as casting, rolling, and forging, but the way a particular method is carried out may contribute in some measure to the pitting resistance. For example, in casting, the rate of cooling may be varied. Heat may be dissipated more rapidly in chilling the molten metal in a cast-iron mold than in sand. The more rapid cooling is less conducive to grain growth in the material and therefore the higher may be the resistance to cavitation. This is borne out by a comparison of specimen no. 70 with 71 in Table 5, no. 138 with 139, and 141 with 142 in Table 8.

The size of the grain can also be influenced by means of alloying elements such as vanadium and molybdenum. This may be demonstrated by the results of three groups consisting of three specimens each listed in Table 5, nos. 60 to 62, nos. 67 to 69, and nos. 76 to 78. For all three groups, which are stainless, 12 per cent chromium steels, the heat-treatments were identical. A comparison between the first and third group shows the beneficial influence of molybdenum, while the higher physicals obtained with nickel as an alloying element in the second group also produced increased resistance.

The effect of nickel additions can be further demonstrated by a comparison of the results obtained with specimens nos. 70 and 72 to 75. Here the successive increases in nickel content reduced the losses step by step. It may be mentioned that the grain structure of this entire series was exceedingly coarse which explains the relatively large losses shown with the lower percentages of nickel in spite of the hardness. This fact is another typical example showing that grain size is of utmost importance and that it should not be neglected even when considering high-alloy steels.

Minor changes in the chemical composition can influence the resistance adversely. Comparing, for instance, the loss of specimen no. 90 with that of no. 97 in Table 6, it will be noticed that the latter specimen suffered considerably more in spite of the greater hardness. This apparent discrepancy is caused by the addition of sulphur in alloy no. 97 to produce a stainless steel of free-machining qualities. The photomicrographic analysis disclosed that sulphur is present in the form of flakes or streaks, producing stress concentrations and facilitating separation along their flanks. At the same time it may be realized that impurities or nonmetallic inclusions, and sulphur in this case may be regarded as an impurity, are detrimental because they are often the nuclei of fatigue cracks and also facilitate their progress. A similar phenomenon is responsible for the comparatively large losses obtained with the forged, stainless, 14 per cent and 17 per cent chromium steels listed in Table 7. Here the carbide-ridge areas seemed to permit quick development and rapid progress of fatigue cracks.

(*b*) *Surface-Treated Materials.* From Table 10 it is apparent that the protection afforded by surface treating depends upon the depth to which the treatment penetrates as well as upon the nature of the skin itself. The large losses obtained with the chapmanized and nitrided materials are due to the shallowness and brittleness of the skins. The penetration with chapmanizing was deeper than that with nitriding which had a decided effect upon the resistance. The large loss with the aluminite finish is not surprising because the skin produced was only 0.001 in. thick so that even the Rockwell tests did not give a true indication of the real surface hardness.

The results with the cloudburst-hardened materials are of interest. Due to the fact that cold working increases the fatigue limit in the strain-hardened zone, this type of treatment has particular merits. This is especially true in cases where machining is required, necessitating reasonably low original physicals, and where subsequent heat-treatment may not be advisable due to possible warpage. It may be noted that a definite maximum in surface hardness can be reached for each material.

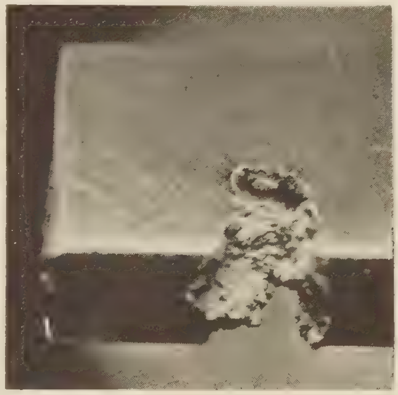


FIG. 10 TYPICAL WATER-JET SPECIMEN
(P.M.G. metal. ×5.)

Carrying the treatment too far, that is, exhausting the capacity of strain hardening, decreases the surface hardness and shows a corresponding increase in loss.

(*c*) *Welded and Sprayed Materials.* In analyzing the results obtained with welding deposits, Tables 11 to 14, various factors must be borne in mind. First, the compositions given refer to the wires and not to the deposits. In the course of welding some percentages of alloying elements may be lost. For instance, the reduction in chromium content of the stainless chromium or chromium-nickel steels may be as much as one per cent. Second, the chemical composition is influenced by the type of coating used. Third, there is an effect from the base metal. That the base as well as the number of welded layers has an influence is demonstrated by specimens nos. 190 to 194, nos. 197 and 198 in Table 12, nos. 223 and 224, and nos. 227 and 228 in Table 13.

Regarding the results in general, the stainless chromium steels showed the best average resistance. Some of the relatively high losses of various austenitic stainless-steel welding deposits of the chromium-nickel variety may be explained to some extent by the improper proportioning of the chromium and nickel contents. The strain-hardening characteristics appear to be rather sensitive to slight changes in the chemical composition. Keeping in mind a possible loss of alloying percentages in the course of welding, too much nickel or not enough chromium in the deposit may impair these characteristics decidedly. For this reason molybdenum may be added to good advantage. A second method of increasing the resistance is demonstrated by specimen no. 241. Here an increased original hardness and a greater susceptibility to strain hardening were obtained by lowering both the chromium and the nickel contents from the usual 18–8 proportioning of chromium and nickel in this variety of steels.

Comparing the losses obtained on welded and sprayed deposits of materials similar in chemical composition, it becomes apparent that welding produces structures of far better resist-

ance. Although spraying may have advantages in many other types of maintenance, the results as presented in Table 15 warrant the conclusion that spraying can be recommended only for temporary repairs or very mild cavitation conditions.

C Pitting Resistance of Materials Exposed to Water Jet

A representative number of specimens consisting of materials identical with some of those exposed to cavitation were prepared for determination of loss due to water jet. These tests were carried out at the East Pittsburgh laboratory of the Westinghouse Electric and Manufacturing Company. The testing apparatus, described in detail elsewhere (6, 7), consists of a 12-in. diameter disk rotating at high speed. Two specimens like that

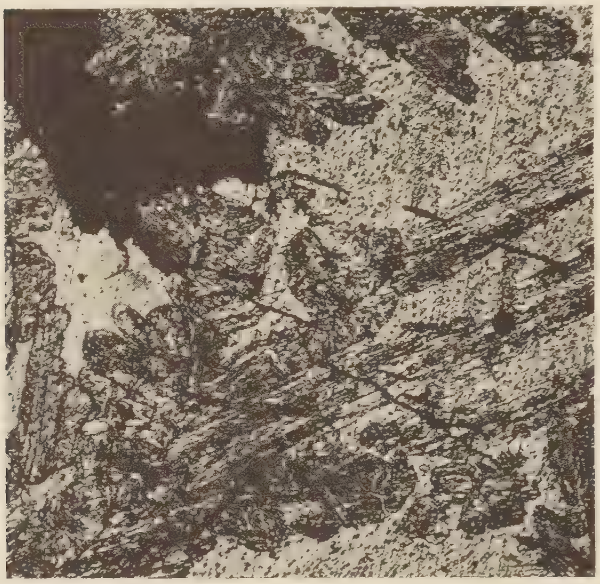


Fig. 11 Welded, Stainless, 18 Per Cent Chromium Steel Pitted by Water Jet
(Note fatigue and cleavage cracks. ×200.)

shown in Fig. 10 can be tested simultaneously mounted diametrically opposite to each other on the outer surface of the rim. There are two nozzles 180 deg apart directing water jets vertical to the plane of the disk. By this arrangement, each specimen is cutting one of the jets at the same time. A peripheral speed of 800 ft per sec was chosen providing 160,000 impacts during the six minutes of test duration. The jet diameters were 3/32 in. and the water velocity 60 ft per sec.

A series of runs carried out with specimens of identical material with the water temperature varying from 2 to 93 C indicated that the amount of pitting is in no way dependent upon the water temperature. This result when compared to that obtained with the cavitation tests leads to the conclusion that cavitation and water impact are fundamentally different. Aside from some minor inconsistencies explainable by the differences in the severity of the punishment, it was found that the losses obtained by the water-jet tests could be grouped similarly to those of the cavitation experiments. From this fact as well as from the photomicrographic analysis, the conclusion is drawn that the various factors governing the rate of pitting are nearly identical for both types of punishment. It is believed that for all practical purposes, the data in Tables 1 to 15 can be used as a guide for the selection of materials exposed to impact due to water jet or drops of water as present in impulse turbines and in the low-pressure stages of steam turbines, respectively.

General Conclusion

From a practical point of view the influence of the temperature indicated in Fig. 4 is important. Pitting apparently is more liable to occur in summer than in winter. In addition more serious consideration must be given to protective measures for equipment to be used in moderate-temperature regions or tropical climates where the water has a relatively high average temperature throughout the year.

The results obtained with air injection, presented in Fig. 5, are of interest because under the velocity conditions usually existing in hydraulic equipment, pitting can be reduced or prevented altogether in some locations, provided sufficient quantities of air can be introduced in such a way that the vulnerable areas are reached by the air. Model tests may be particularly helpful in obtaining proper guidance of the air. This is important because an adequate percentage of artifically introduced air over the entire water passage would be prohibitive from an economic point of view.

It is believed that the comparative data on the pitting resistance presented in this paper will be helpful in providing a more rational selection of materials for new installations, or for maintenance of structures or integral parts of hydraulic equipment subject to attack by cavitation. Although the number of materials investigated is necessarily limited, nevertheless the findings of the metallographic studies broadened the metallurgical aspects of failures due to cavitation to such an extent that, under modern manufacturing procedures and advanced scientific control of production, and with the aid of the results at hand, the pitting resistance of almost any metallic material can be predicted with sufficient accuracy. It must be borne in mind, however, that the resistance may not always be the only factor coming into play. Compromises may have to be made to satisfy all requirements including those dealing with the methods of manufacture and production, as well as the cost of the material and other economic considerations.

Acknowledgments

This research was made possible through the support received from J. A. Walls, president, Safe Harbor Water Power Corporation. The interest and cooperation shown by the research and metallurgical departments of steel and alloy manufacturers too numerous to mention individually are responsible in a large measure for the progress made. The author is particularly indebted to H. N. Boetcher, assistant to the superintendent of steam stations, Consolidated Gas Electric Light and Power Company, Baltimore, Md., and S. P. Watkins, metallurgist, Rustless Iron and Steel Corp., Baltimore, Md., for their contributions to the metallographic phase of this research.

BIBLIOGRAPHY

1 "Werkstoffzerstörung bei Kavitation" (Material Destruction Through Cavitation), by H. Schröter, *Zeitschrift V.D.I.*, vol. 78, March 17, 1934, pp. 349–351.

2 "Pitting in Water Turbines," by Elov Englesson, *The Engineer*, vol. 150, Oct. 17, 1930, pp. 418–421.

3 "Investigation of Corrosion Phenomena in Water Turbines," by P. de Haller, *Escher-Wyss News*, vol. VI, no. 3, May-June, 1933, pp. 78–84.

4 "Failure of Metals Due to Cavitation Under Experimental Conditions," by H. N. Boetcher, Trans. A.S.M.E., vol. 58, 1936, paper HYD-58-1, pp. 355–360.

5 "Die Zerstörung von Metallen durch Kavitation" (The Destruction of Metals Through Cavitation), by H. N. Bötcher, *Zeitschrift V.D.I.*, vol. 80, Dec. 12, 1936, pp. 1499–1503.

6 "Recent Developments in Steam Turbines," by C. R. Soderberg, *Mechanical Engineering*, vol. 57, March, 1935, pp. 165–173.

7 "Turbine Blade Erosion," by C. R. Soderberg, *The Electrical Journal*, vol. 32, Dec., 1935, pp. 533–536.

Cavitation on Marine Propellers

By LYBRAND P. SMITH,[1] WASHINGTON, D. C.

The author defines terms used in connection with cavitation of marine propellers and hydraulic turbines. He points out that cavitation is a problem of growing importance where higher powers and speeds are required, and when cavitation occurs that thrust, torque, and efficiency are reduced and erosion of the hardest metals occurs. Theoretical and experimental research into the mechanics of cavitation and its effect on thrust, torque, and efficiency is reported. The author reports that the standard or usual equations for thrust and torque are merely special cases of a general thrust and torque theorem which he develops. He points out that cavitation on marine propellers is a phenomenon different from anything occurring on aerial propellers.

The author discusses the following items in detail: (*a*) In the general case, thrust and torque coefficients are functions of slip ratio, rotary speed, and pressure, and are not merely functions of slip ratio alone as is generally assumed. (*b*) For thrust and torque coefficients to be treated as functions of slip ratio only, the propellers must operate at low rotary speed or under high-pressure conditions. (*c*) Marine propellers operate under low-pressure conditions. (*d*) A simple equation indicates where burbling cavitation will begin on the back of any blade elements and what can be done to delay the appearance of such cavitation. (*e*) A vortex, in which the water particles move in approximately helical paths around the axis, is prerequisite to laminar cavitation. (*f*) A laminar cavity is not in contact with the propeller blade, but is separated therefrom by a wall of water. (*g*) Both kinds of cavitation can actually reduce thrust and torque with increasing rotary speed, and not merely reduce the thrust and torque below the values which would have been attained in the absence of cavitation, as is usually assumed. (*h*) After either type of cavitation completely covers the back of propeller blades, thrust and torque will increase again with increasing rotary speed, although at a lesser rate than in the absence of cavitation. (*i*) Both kinds of cavitation result in an increase of pressure on the cavitating side of the blade in excess of the pressure which would have existed in the absence of cavitation, and this accounts for the relatively small effect on thrust and torque when cavitation occurs on the face of the blade.

In conclusion, the author shows that previously reported explanations are inadequate to account for all the observed effects of cavitation on thrust and torque. He then develops his own theories to explain such effects, and shows that insight into actual physical phenomena has frequently been obscured by the otherwise useful custom of plotting results in the form of dimensionless, or quasi-dimensionless, coefficients against dimensionless products such as Reynolds' numbers or slip ratio.

1—INTRODUCTION TO THE EXPERIMENTS

A Field of Experiments in This Paper

THERE is a vast multitude of problems concerning marine propellers awaiting solution; but acting on the principle that one should "refrain from attempting too wide a field of inquiry," this paper will be confined to certain problems arising out of or in connection with the fact that cavitation occurs.

B Cavitation Definitions

Considerable confusion has arisen in the literature of cavitation by reason of the writers not having defined their terms. Usually they merely say "cavitation" or "cavity." More rarely they recognize two kinds of cavitation—"laminar" cavitation and "burbling" cavitation. Neither of the two preceding adjectives is particularly appropriate, but they have come into general use among writers who recognize that cavitation occurs in two quite distinct forms. To avoid confusion in comparing this paper with arguments of other writers the adjectives "laminar" and "burbling" will be retained, and defined along with other terms.

Definitions of the terms used in this paper are as follows:

(*a*) A cavity within a liquid is a single space void of liquid and bounded by a single surface, which may be wholly liquid or part liquid and part solid.

(*b*) A laminar cavity is a cavity stretched out in a long thin sheet or tube.

(*c*) A burbling cavity is a cavity in the form of a bubble, i.e., roughly spherical or in some cases hemispherical.

(*d*) A cavitation field is a region in a liquid bounded by a single envelope and containing a plurality of cavities—usually burbling cavities, but occasionally laminar cavities.

(*e*) In addition to defining cavitation by types it is sometimes referred to by location as tip, root, leading edge, trailing edge, face or back cavitation. None of these terms needs definition except "face" and "back." The face of a blade is the pressure side. The back of a blade is the suction side.

The foregoing definitions may be objected to as not being "operational" as Bridgman (1)[2] so rightly argues that scientific definitions should be. However, in the experiments subsequently described the operations will be indicated by which the

[1] Commander, United States Navy, Staff of Commander Battleships, Battle Force, U.S.S. *West Virginia*, flagship. Commander Smith was graduated from the United States Naval Academy in 1911, and later attended the University of Santo Domingo in 1919–1920, and the American University in 1933–1935; he received from the latter his D.Sc. degree in 1935. He served at sea from 1911 to 1919. From 1919 to 1921, during the military occupation of Santo Domingo, he held several cabinet posts in the Dominican Republic. He was commercial superintendent of Naval Communication Service from 1921 to 1923; senior assistant engineer, U.S.S. *Colorado*, 1923–1924, and chief engineer, 1924–1926. He was assigned to the repair division, Bureau of Engineering 1926–1928. Then he became Commanding Officer of the U.S.S. *Zeilin* and later the U.S.S. *Claxton*, 1928–1931. He was Officer-in-Charge of the U. S. Naval Boiler Laboratory from 1931 to 1933. He moved next to the boiler desk, design division, Bureau of Engineering and then in 1934 was assigned to the propeller desk of the same division with additional duty for research at the U. S. Experimental Model Basin. He was transferred to his present duty in 1936.

Contributed by the Hydraulic Division and presented at the Joint meeting of the Applied Mechanics and Hydraulics Divisions of The American Society of Mechanical Engineers, held at Cornell University, Ithaca, N. Y., June 25–26, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until September 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Note: Statements and opinions advanced in this paper are to be understood as individual expressions of the author, and not those of either the U. S. Navy Department or of the Society.

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

cavities can be created and be seen; and illustrations of actual cavities will be shown.

C Harmful Effects of Cavitation

Cavitation produces two seriously harmful results: (*a*) It causes rapid erosion, or corrosion, of propeller blades. (*b*) It reduces propeller thrust and torque; and usually efficiency.

Cavitation erosion will not be considered in this paper, although it is a live and important subject, with an extensive literature which a few works from one country (Germany) for one year will indicate (2, 3, 4, 5, 6). Nevertheless, cavitation erosion might be eliminated entirely, possibly by improvements in metallurgy, without in any way reducing cavitation or its effects on thrust and torque. On the other hand, the harmful effects on thrust cannot be reduced or eliminated without reducing or eliminating cavitation. Success with the erosion problem merely alleviates a symptom, success with the thrust problem cures the disease.

The author will deal mainly with marine propellers operating in or near the conditions under which cavitation may occur.

D Fundamental Difference Between Aerial- and Marine-Propeller Problems

Although the term "cavitation" is sometimes used loosely in connection with aerial propellers, it should be noted most emphatically that nothing in connection with aerial propellers corresponds to the cavitation of marine propellers.

In the latter case we have liquid water surrounding a space which is void of liquid, but which is filled with water vapor, usually mixed with air or other gases which have been dissolved in the water and are set free with the vapor as soon as the cavity is formed. We have, if you like, two different fluids, liquid water and a gaseous mixture.

In the former case we have regions of different pressure and density, but we do not have and cannot obtain a condition of separation into two fluids. We have only one fluid—air.

By the use of dimensionless products (for example, Reynolds' numbers) we can formulate many hydrodynamical equations or obtain empirical curves which are identical for a wide range of fluids such as water, oils, air, and various gases, flowing around solid bodies or through channels with rigid walls, so that experimental results with one fluid may safely be used for predicting the behavior of others. But in all such cases we are dealing with one continuous fluid at a time, while in the study of the cavitation of marine propellers the case is quite different. In this latter case we have to do with two separate fluids; and curves or equations that may be valid up to the beginning of cavitation cease to be applicable after the separation into liquid and gaseous phases, and cannot be used for extrapolation beyond this point.

E The Thrust and Torque Theorem

In short, if a marine propeller is operating in or near cavitation conditions it must be expected that equations used to describe its action will be more complex than those used to describe the action of an aerial propeller, or a marine propeller far outside of cavitating conditions. The nature of such equations is formulated as a theorem in this paper, and it will be shown that the standard equations used to describe propeller action are merely special cases of the more general equations.

It may be asked how such general equations will serve a useful purpose. As Sir Oliver Lodge said: "The answer is quite definite. The mathematical physicist probes down into the fundamental activities, so as to be able to formulate in his mind what is really going on, and to express the actions which can be observed in a definite and quantitative form called an equation, especially in that form called a differential equation, which expresses interactions among the smallest parts (7)."

This is to say that when a physicist has formulated such equations he has a definite picture in his own mind as to what is really going on, and this picture guides him to the experiments he should make to find the actual nature of the several factors in his equations. That has been the case in the present paper and the experiments made have yielded fruitful results. Among these results was emphasis on the previously known fact that pressure may play an important part in the performance of propellers, and this emphasis occurred in such a form as to raise the question: Do actual marine propellers normally operate within the range in which pressure is an important factor?

F The Pressure on Actual Propellers

The previous question led to a study of the pressure conditions on propellers for sea-going ships. The results of that study clearly show that, except in the case of deeply submerged submarines, marine propellers generally operate well within the range where pressure is an important factor in their performance. Therefore, pressure must be considered in the case of actual propellers.

G The Location of First Burbling and Laminar Cavitation

Cavitation has been shown to be an evil. To prevent an evil, one of the best methods is to learn where it begins and to eliminate it there. A deductive analysis will be made to find a theoretical answer to the problem: "Where does cavitation begin?" A verification of the resultant hypothesis will be sought and found in experimental observations.

H The Reason Cavitation Reduces Thrust and Torque

The general thrust and torque theorem formulated in this paper, the special cases of that theorem which are commonly accepted in standard texts, and the standard theories of propeller action do not indicate why cavitation reduces thrust and torque. Writers generally touch this subject very lightly, admitting or proving the occurrence of the phenomenon, but only hinting at a hypothesis for its explanation. From such writings tentative hypotheses will be formulated and discussed, and reasons shown for rejecting them. Then, in the present paper, a detailed discussion of the mechanics of cavitation will be given and a hypothesis will be formulated regarding how it produces the observed effects on thrust and torque. Experimental verification of the hypothesis will be given from experiments performed by other people for different purposes, and from experiments performed by the author for the particular purpose.

2—THRUST AND TORQUE THEOREM

A The Theorem

A fruitful method of studying the performance of any machine is to study the variations of its performance. Now it is an obvious platitude that while constants affect the absolute values in performance they do not and cannot cause variations in performance.

Thus, in the case of a given propeller such factors as its diameter, pitch, shape of blade, and roughness of surface, are constant. They affect the absolute values of that propeller's performance, but in no way can they be the cause of variations in its performance.

The two things we can vary in connection with the propeller itself are its revolutions per unit time N and its slip ratio S.[3]

[3] Slip ratio or slip is defined as $[1 - (v/pn)]$, where p = pitch of propeller, ft; n = propeller speed, rps; and v = speed of advance relative to undisturbed water, fps. When the pitch is variable, the mean face pitch at 0.7 radius is used as a matter of convention in defining the slip.

All other variables are properties of or refer to the surrounding medium itself.

Variations of the acceleration of gravity and of the compressibility of water are so slight (8) that for investigating marine propeller phenomena those factors may be considered constants which do not cause variations in performance.

Density, vapor pressure, viscosity, and surface tension of water all vary with temperature. Based on long experience at sea, the author will state that for practical purposes variations in the water temperature may be considered limited to the range between 4 and 35 C (39.2 and 95 F). To show the approximate magnitude of the variations produced in density, vapor pressure, viscosity, and surface tension by changes of temperature, the following data are extracted from the Smithsonian Physical Tables (9):

Temperature, C	4	35
Density, grams per ml	1.00	0.994
Vapor pressure, mm of Hg	6.10	42.23
Viscosity, centipoises (1 poise = 1 dyne-sec per sq cm)	1.57	0.72
Surface tension, dynes per cm	75	70.3

From the preceding data it is seen that density varies less than 1 per cent over the entire range of temperatures likely to be encountered. Since density is known to enter the performance equations as a linear function variations of density due to variations of temperature may be ignored. The difference in density between fresh and sea water, however, is over 2 per cent and cannot be ignored. In passing from fresh water to the average sea water the density changes from 1.0 to 1.024 at 39 F according to Saunders (10); but, as shown by Taylor (12), if we test a propeller in fresh water we can predict the results in sea water by multiplying the thrust and torque obtained in fresh water by 1.024.

Variations in surface tension may conceivably cause variations in formation of cavities. Variations in viscosity certainly must produce some variation in the frictional drag on propellers. But the net effect of these variables apparently may be ignored with safety, since it is so small that it has not been detected in the performance of the more than 1500 model propellers which have been tested by the personnel of the U. S. Experimental Model Basin to date (1936).

The vapor pressure of water e varies too much and in too great an amount to be ignored, particularly when cavitation on a small propeller is likely. At 39.2 F the vapor pressure is equivalent to the pressure of 0.27 ft of water; and at 95 F increases to 1.89 ft of water.

The absolute pressure P at the propeller axis is obviously the sum of the atmospheric pressure on the surface of the water and the pressure due to the submergence of the propeller. This absolute pressure P can be expressed, of course, in the same terms as e; for example, in ft of water.

It is logical then to combine P and e, if possible, in order to reduce the number of variables. Note that if P is varied, either by a change in atmospheric pressure or in depth of submergence, the result is merely to change the static pressure by the same amount at all points in the water and is not to change the pressure gradients. But, if at any time at any place in the liquid $P - e = 0$ the liquid will boil at that place except under highly specialized conditions of cohesion experiments such as reported by Newton (16), Dixon and Joly (17, 18) and Livingston and Lubin (19, 20). This may be expected to disturb the pressure gradients and consequently the forces acting on the propeller.

Hence, let H be a new variable compounded of P and e such that $H = P - e$ = pressure in excess of vapor pressure at the propeller axis; and let it be expressed in terms of feet of pure water.

Clearly, then we have so limited the number of significant variables that we can write

$$T = f(S, N, H) \qquad [1]$$

$$Q = \phi(S, N, H) \qquad [2]$$

where T is the thrust in lb; Q is the torque in lb. at 1 ft radius; as previously defined, S is the slip ratio;[3] N is rpm; and H is the pressure in excess of vapor pressure at the axis of the propeller.

One of the most fruitful methods to study Equations [1] and [2] would be by the method of dimensional analysis. Taylor (12) has followed this method though he has ignored H in all his equations, and merely reports the results of a few experiments when H is reduced, without endeavoring to determine how that quantity should enter the equations. Schaffran (21) and Baker (22) have followed a procedure analogous to Taylor's (12). An article by Buckingham (25), published after the preparation of this paper, is believed to be the most thorough study to date of dimensional analysis with propellers, and is probably the only one which fully applies this mathematical principle to cavitation.

It is believed that the method of dimensional analysis is the most all around useful method for this purpose. However, it has been very thoroughly exploited—in spite of previous writers other than Buckingham not having included H in their dimensional equations—and the author believes that new experiments will be suggested, a new viewpoint will be gained, and possibly a further insight into the mechanism of cavitation will result if Equations [1] and [2] are studied by another method.

The method proposed is to convert Equations [1] and [2] into differential equations. Doing this we obtain

$$dT = \frac{\partial T}{\partial S}dS + \frac{\partial T}{\partial N}dN + \frac{\partial T}{\partial H}dH \qquad [3]$$

$$dQ = \frac{\partial Q}{\partial S}dS + \frac{\partial Q}{\partial N}dN + \frac{\partial Q}{\partial H}dH \qquad [4]$$

Equations [3] and [4] constitute the thrust and torque Theorem.[4]

This theorem almost automatically directs us to perform systematic experiments or operations with everything constant except S; with everything constant except N; and with everything constant except H. We would thus obtain what might be called: (*a*) T-S and Q-S curves; (*b*) T-N and Q-N curves; (*c*) T-H and Q-H curves.

In view of the foregoing discussion this may seem a perfectly obvious procedure. But apparently it is not. In the examination of a very wide range of literature the author has discovered only one set of experiments with a variable H and a constant S and N, but the exact variation of H was not given as only the variation of P was mentioned, and the water temperature was not recorded. All "characterization curves" are forms of the T-S and Q-S curves; but since they are expressed in the form of thrust and torque coefficients they are supposed to be good for any values of N and there is rarely any indication at what N they were obtained. By questioning people who obtained such curves the author has found that it is not at all unusual to vary N at convenience during any one test. He has never in any case found an experiment with S and H held constant while N was varied. And especially, he has never found a case where the

[4] According to Funk and Wagnall's New Standard Dictionary a theorem is, among other things: "A proposition not self-evident that is demonstrably true or acknowledged as such; . . . a rule or law formulated in symbols, or the directory of an operation."

complete set of operations directed by the thrust and torque theorem was carried out for any one propeller.

Since Equations [3] and [4] are similar in form, only Equation [3] for thrust will be discussed in detail; although experiments directed by the theorem will be made to demonstrate that both Equations are true.

B Usual Equations Are Special Cases

The standard or usual equations for the thrust and torque of a given propeller are merely special cases of the foregoing more general theorem.

The standard equation for thrust as given by Taylor (13) is

$$T = C_T n^2 p^2 d^2 \qquad [5]$$

where C_T = thrust coefficient; n = propeller speed, rps; p = pitch of the propeller; d = propeller diameter; and there is a similar equation for torque involving p^3 in place of p^2. Shaffran (21) uses equations of the same form as Taylor's. These standard equations are entirely analogous to standard equations for lift of airfoils (26), such as

$$L = {}^1/_2 C_L \rho V^2 A$$

where L = lift; V = velocity; A = area of foil; ρ = density of medium; and C_L = experimentally determined lift coefficient.

In Equation [5], d^2 corresponds to A in the lift equation; N^2p^2 at a given slip corresponds to V^2 at a given angle of attack; and ρ does not need to appear in Equation [5], because it is sensibly constant for water.

Equation [5] is, in reality, a definition of C_T, because by writing it in the form

$$C_T = \frac{T}{n^2p^2d^2} \qquad [6]$$

we can always get a definite value of C_T, for a propeller of known pitch and diameter, by substituting simultaneously observed values of T and N. Thousands of such determinations of C_T for hundreds of model propellers have been made in open-water tests in which the propellers have not been driven up to the cavitation point. When the values of C_T, obtained from such tests of any one model propeller, are plotted against the slip ratio S, the points lie so closely along a single curve that it is reasonable to assume that deviations from the curve are due to accidental errors of measurement, and thus to assume that, in the absence of cavitation, C_T depends only on S, so that

$$C_T = f(S) \qquad [7]$$

Equation [5] may then be rewritten as

$$T = p^2d^2n^2f(S) \qquad [8]$$

or letting $p^2d^2 = k$ = a constant for the given propeller

$$T = kn^2f(S) \qquad [9]$$

This is of the general form

$$T = f(N, S) \qquad [10]$$

N being by definition the number of revolutions in *any* unit of time

whence

$$dT = \frac{\partial T}{\partial N}\,dN + \frac{\partial T}{\partial S}\,dS \qquad [11]$$

Therefore, it may be said that the standard Equation [5] as usually understood on the tacit assumption that there is no cavitation, is a special case of the more general equation, that is, Equation [1].

When we drop this restriction regarding cavitation, Equations [7] to [10], inclusive, are no longer adequate. Taylor cites a case (14) illustrative of results obtained in the variable-pressure water tunnel at various constant values of total absolute pressure, which of course would correspond to various constant values of the total head H above vapor pressure. (See the discussion under section 2A of this paper.) Under such conditions the curves of C_T versus S do not coincide over their whole range; on the contrary, at high values of S the value of C_T for a given value of S depends on H. Hence, although Taylor does not state it in just this way, we know that, in general C_T depends on H as well as on S.

From this we might incautiously infer that C_T depended only on S and H, and write in place of Equation [7]

$$C_T = F(S, H) \qquad [12]$$

which would put Equation [5] into the form

$$T = kn^2 F(S, H) \qquad [13]$$

The inference would, however, be incorrect; for as will be demonstrated clearly in the following sections reporting the author's experiments, C_T is not completely determined by S and H but depends also on N, so that in place of Equation [12] we must write

$$C_T = F_1(S, N, H) \qquad [14]$$

and in place of Equation [13]

$$T = kn^2 F_1(S, N, H) \qquad [15]$$

But this is merely a statement that

$$T = f(S, N, H) \qquad [16]$$

which is the original Equation [1].

Equation [15] makes it evident that, in general, the variations of T with N alone follow a more complicated law than $T \propto N^2$, as indicated by Equation [9] although Equation [9] is adequate for practical purposes to represent the results of open-water tests which stop short of cavitation. The experiments to be described show that the simpler relation is a special case of the more general theorem, and that in order to get the simpler relation it is necessary to avoid cavitation by making the total head above vapor pressure H large; or the rotary speed N small.

A similar chain of reasoning and the same experiments prove that in general the torque coefficient C_Q, is

$$C_Q = F_2(S, N, H) \qquad [17]$$

and that the torque Q is

$$Q = kn^2 F_2(S, N, H) \qquad [18]$$

C Nature of the Experiments[5]

In Equation [3] the partial differential coefficient of T with respect to S, i.e., $\partial T/\partial S$, is the rate of change of thrust with respect to slip alone. Hence, if N and H are held constant at any values and S is varied we obtain a T-S curve. The slope of this curve at any point is obviously $\partial T/\partial S$. It would be possible, of course, to produce families of T-S curves for various constant values of N and H. A similar procedure with respect to Q yields the Q-S curves.

[5] The experiments reported in this paper were all conducted at the U. S. Experimental Model Basin, Washington, D. C., and especially in the variable-pressure water tunnel. For a description of the apparatus see articles by Saunders (10, 32). Since Saunders last-mentioned article (32) was written, the principal improvements in the water tunnel have been (*a*) better control and measurement of water velocities; (*b*) heat insulation of the tunnel; (*c*) the installation of an Edgerton stroboscope; and (*d*) photographic apparatus.

The same remarks apply to the partial differential coefficients $\partial T/\partial N$, $\partial Q/\partial N$, $\partial T/\partial H$, and $\partial Q/\partial H$. In gathering the data which could yield numerical values for these coefficients we should obtain families of *T-N*, *Q-N*, *T-H*, and *Q-H* curves.

In order, then, to demonstrate that the thrust and torque theorem is true, and sheds some light on marine-propeller phenomena not yielded by the standardized equations, experiments of the following nature are necessary: (*a*) Determine the *T-S* and other curves previously mentioned. (*b*) Study them to see if they indicate any phenomena not predicted by the standard equations; and if so (*c*) try to account for such phenomena by observing cavitation characteristics, if any.

It would be desirable, of course, to run all of these curves over a very wide range to obtain a large family of such curves, and to do this for a large number of propellers.

The limitations of the apparatus prevent as wide a range of observations as would be desirable. It is obvious that there would be upper limits to the water speeds, revolutions, thrust torque, and pressures which could be placed on any particular apparatus. It is not so obvious, but equally true that for practical purposes there are lower limits, particularly in the case of water speeds. At very low water speeds it is practically impossible to control conditons in the tunnel, because minute changes will cause the propeller under test to control the water speed at times, and at other times the tunnel's impeller will control it. The result is a series of irregular surges, which render observations useless. It may be stated now that in every case the experiments were run over as wide a range as physically permissible with the available apparatus.

Time and funds available prevented obtaining as large a family of curves for as many propellers as desirable. There is only one variable-pressure water tunnel and it is in almost constant use on urgent government work. The best procedure seemed to experiment as thoroughly as possible with a few propellers, and to observe all the routine governmental tests possible. Should the latter, which cover a wide variety of propellers under a wide variety of conditions, ever yield an observation at variance with the hypotheses resulting from the experimenter's research, that would be definite evidence that something was wrong with his hypotheses. The absence of such negative instances would not prove his hypotheses right. The lack of negative instances would merely increase the probability that the hypotheses were right. For example, there is no *a priori* reason to assert that "The uniformity of nature" is a true hypothesis. But after diligent search over a wide field a negative instance has never been found. This increases the probability that the hypothesis is right.

D Selection of Propellers for Experiment

Since, as stated previously, the actual experiments had to be limited to a few propellers, and since it is desirable to study cavitation, it seemed wise to find two propellers differing as widely as possible in their cavitation characteristics.

There are two radically different kinds of cavitation—"burbling" and "laminar" as stated previously. The characteristics of about 1200 model propellers were studied and two groups selected, one of which was likely to cavitate mainly in the laminar manner and the other in the burbling manner. These limited groups were then run through cavitation to check the records, and propeller model No. 1283-*A* was selected as the most typical of laminar cavitation,[6] and propeller model No. 414 was selected

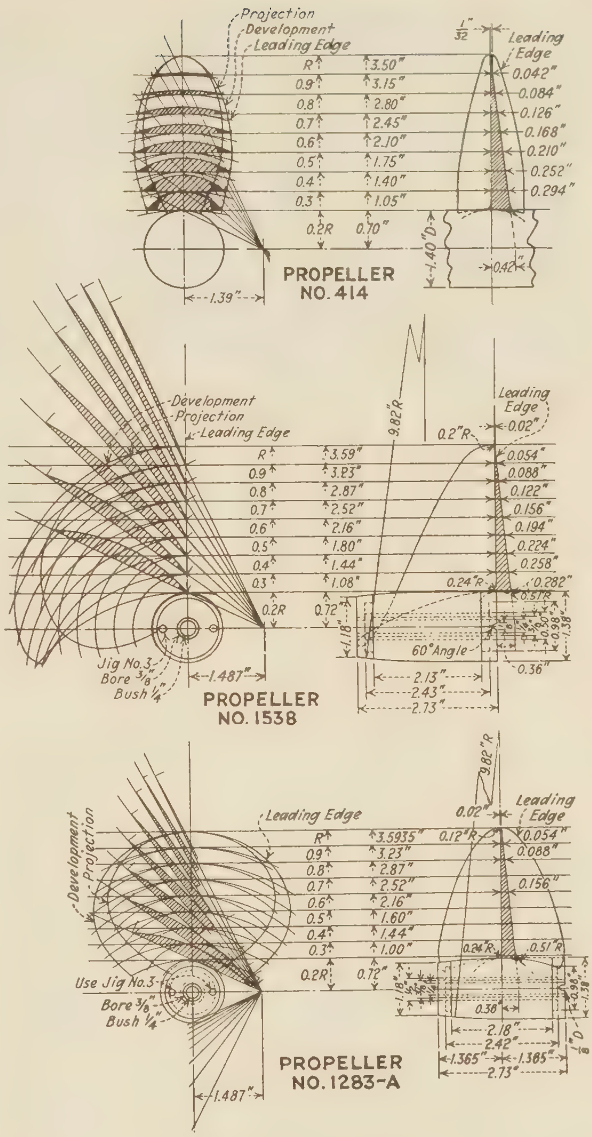


Fig. 1 Details of Propellers Selected for Cavitation Tests

Characteristics of the Propellers

Propeller no.	414	1583 and 1283-*A*
Diameter, in.	7.000	7.187
Pitch, in.	8.750	9.340
Pitch ratio	1.250	1.300
Mean width ratio	0.200	0.500
Number of blades	3	3
Total projected area	9.432	25.580
Ratio of projected area to developed area	0.245	0.630
Blade thickness fraction	0.060	0.050
Direction of rotation	right	right
Length of sections from T.E. to maximum ordinate at the following percentages of the radius:		
20	0.657	1.443
30	0.737	1.683
40	0.832	1.883
50	0.870	2.063
60	0.860	2.200
70	0.804	2.257
80	0.707	2.163
90	0.535	1.733

as the most typical of burbling cavitation. As an additional check one freak-type propeller (No. 1538) was manufactured for comparison with No. 1283-*A*, all dimensions being held as nearly the same as was possible for the pattern maker to work, the es-

[6] Propeller model No. 1283-*A* was originally No. 1283. A small amount of metal was scraped from the back near the leading edge of the root sections, and the designation *A* added to call attention to the fact that a slight change had been made. All experiments reported in this paper were made after this minor alteration.

sential difference being to shift the tangential sections to make the leading edge a radial straight line.

The complete details of these propellers are shown in Fig. 1. The open-water characterization curves of propellers 1283-*A* and 414 are shown in Fig. 2. Fortunately some of the low-pressure runs were made with propeller 1538 before any attempt was made

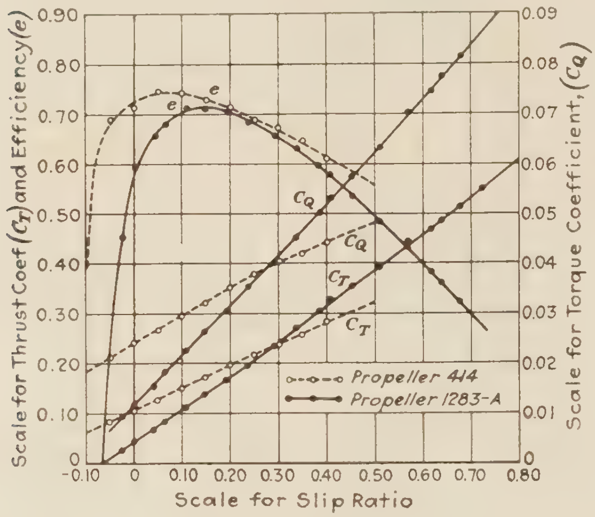


FIG. 2 OPEN-WATER CHARACTERISTIC CURVES FOR PROPELLERS 414 AND 1283-*A*

($C_Q = Q/n^2p^3d^2$; $C_T = T/n^2p^2d^2$; $e = Tv/2\pi Qn$; and Slip $S = (pn - v)/pn$ where Q = torque, ft-lb; T = thrust, lb; n = rps; v = speed of advance, fps; p = pitch, ft; and d = diameter, ft.)

to obtain its open-water characteristics; because, owing to its freak construction, it was inherently weak. The blades bent while running experiments to obtain the *T-N* and *Q-N* curves; they were repaired, and then the propeller was run to destruction as the higher pressures were reached while obtaining the *T-H* and *Q-H* curves.

[Editor's note: Sections *E*, *F*, and *G* of part 2 of the paper which follow have been condensed. However, the author's original manuscript giving details of all his observations is on file in the archives of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, together with excerpts from a letter in which he discusses probable error.]

E EXPERIMENTAL DETERMINATION OF THE *T-S* AND *Q-S* CURVES

The set of tests which should be first considered, the results of which are presented graphically in Fig. 3, were made with constant pressure *H* in excess of vapor pressure and with constant revolutions *N* for each series, the slip ratio *S* being varied in order to show thrust *T* and torque *Q* as functions of *S*.

For propeller 1283-*A*, three series of runs were made at 800, 1200, and 1600 rpm, respectively. The water temperature was 76 F for all runs corresponding to a vapor pressure of 1.02 ft of water, and *H* was maintained at 2.00 ft. For propeller 414, two series were made at 855 and 1282 rpm, respectively, and although the temperature of the water varied slightly, *H* was as before maintained at a constant value of 2.00 ft of water. Unfortunately no comparable tests could be made for propeller 1538 for the reason that this propeller failed mechanically during tests that although conducted earlier are more logically discussed in the following section of this paper.

Fig. 3 shows the characteristics of the two propellers that could be tested in this way, and brings out very forcibly the essential fact that in the general case thrust and torque are not simple functions of *S* alone; and that *T* and *Q* vary with *N* by some relation that is more complicated than the second power. In order to make a little more clear the fallacy of the simple equations used at the outset of this paper, the observed values have been reduced to thrust and torque coefficients and plotted for comparison with the corresponding open-water curves taken from Fig. 2. It is to be noted that in the case of propeller 1283-*A* most of the points fall sufficiently close to these repeated curves to indicate that the fundamental equations do hold up to a point where there is a definite breaking away, and that from there on the relation is complicated. In the case of propeller 414, the observations for the lower speed agree reasonably with the previously determined open-water curves, but for the higher speed something has already taken place even at the lowest slip ratio for which measurements were taken, which causes both the torque and the thrust to be not in accordance with the open-

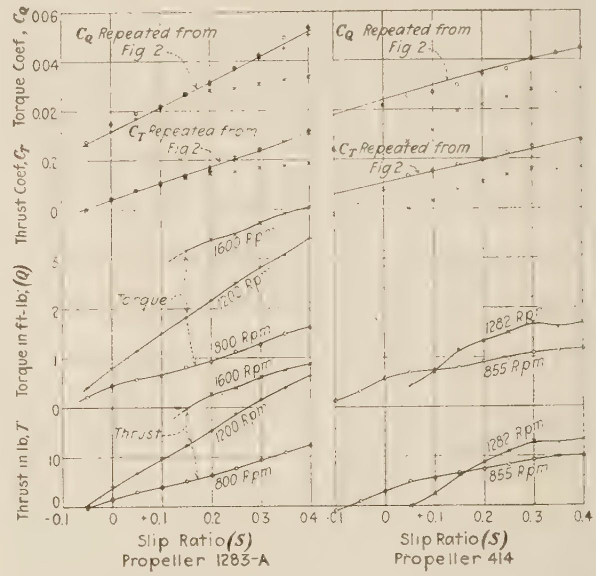


FIG. 3 SLIP CHARACTERISTICS OF PROPELLERS 414 AND 1283-*A*

(Pressure *H* at hub, in excess of vapor pressure = 2 ft of water. Note that at 1282 rpm propeller 414 cavitates even at low slip ratios.)

water tests. In fact, the effect is so marked that there is an actual crossing of the observed curves, and it should be noted particularly that until the slip is near 20 per cent this propeller gives less thrust at 1282 rpm than it does at 855 rpm.

It is obvious that since thrust and torque are shown so conclusively to vary not by any simple function of N^2, it is necessary when presenting curves C_Q and C_T as functions of *S*, that *N* at which the values were obtained should be indicated.

The following step is to investigate further the influence of *N*.

F EXPERIMENTAL DETERMINATION OF THE *T-N* AND *Q-N* CURVES

In the preceding section 2E it was demonstrated that *N* did have an influence on the characteristic *T-S* and *Q-S* curves. The task is now to investigate further by holding other elements constant and varying *N* progressively, at the same time observing visually the appearance of the back side of the blade and repeating with different values of pressure *H* and slip ratio *S*. Furthermore, all three model propellers were used to demonstrate the characteristic differences in type of cavitation arising from the peculiarities of design.

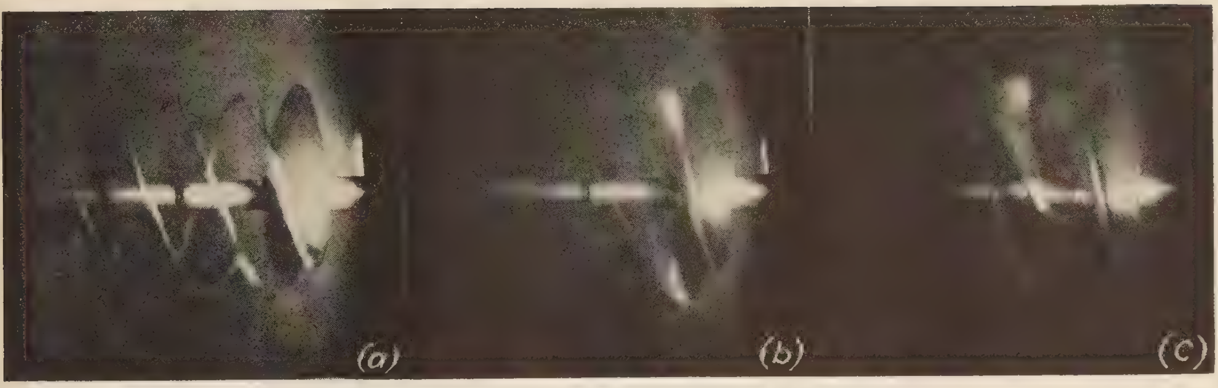


Fig. 5 Propeller 1283-A as Seen by Light of the Edgerton Stroboscope Operating at Three Different Speeds With 35 Per Cent Slip in Water Pressure of 1.37 Ft in Excess of the Vapor Pressure. The Water Flow Is From Right to Left

((a) At 924 rpm the dark patch which appears to rest on the tip of the back (suction side) of the blade is laminar cavitation, so called because from this point of view it appears as a thin, smooth, sheet-like cavity lying on the blade. Note that this cavity trails astern like a twisted ribbon. (b) With the speed increased to 1155 rpm the laminar cavity has covered more of the back. To the eye, when accommodated to the light, the vortices trailing astern did not present such a frothy appearance as in the photograph (which consists of pictures taken by about ten flashes superimposed on each other), but did appear as a larger form of the tip vortices shown in (a). (c) Speed still further increased to 1616 rpm. The laminar cavity now extends nearly to the root of the blade and covers practically the entire back.)

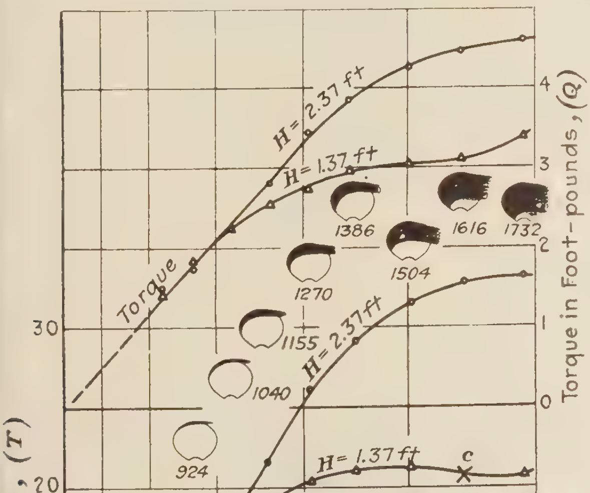


Fig. 4 Torque-Speed and Thrust-Speed Curves for Propeller 1283-A at Two Pressures

(Letters a, b, and c refer to Fig. 5. H = pressure at hub, in excess of vapor pressure, ft of fresh water. Slip ratio = 0.35. Black shading indicates laminar cavitation while dotted shading indicates burbling cavitation; the proportion of blade area covered by cavitation as indicated is probably correct within ± 5 per cent. Cavitation indicated is all on the back (suction) side of the blade.)

Fig. 4 shows T and Q plotted against the square of the speed for the first two runs on propeller 1283-A, the slip in both cases being 0.35, but H in the first run was 2.37 ft of water in excess of the vapor pressure and 1.37 ft in the second. There is evidence that both the torque and the thrust vary in direct proportion to the square of the speed only to the point where cavitation becomes evident. For both pressures this ratio is the same, but at the lower pressure the breaking away from the common straight line is at a much lower value than for the higher pressure. It will be seen that the break away is intimately connected with the change of appearance of the back side of the blade.

Fig. 5 shows illustrations a, b, and c taken at the stages in this second series marked by the points a, b, and c on Fig. 4.

In order to demonstrate more clearly than was possible with the conditions selected for the first two runs, two conditions were changed in the third, both being conducive to greater cavitation. In the first place the slip was increased from 0.35 to 0.45, and also the pressure was still further lowered to 1.04 ft of water. As will be seen later, this third run affords a much better comparison with the other models and lays a foundation for the subsequent argument.

The results of this series are shown in Fig. 6. The straight diagonal lines from which the test curves would have broken away if they had been carried downward to the range of very low speeds were derived from the open-water tests and the dashed portion of the curve seems amply justified in the light of the previous results. The form of both the T-N and Q-N curves is very important and should be carefully noted on account of the subsequent importance in the development of the theory proposed. Terms $\partial T/\partial N$ and $\partial Q/\partial N$ will be referred to frequently, and it should be remembered that $\partial T/\partial N$ and $\partial Q/\partial N$ are simply the slopes of these two curves, which will be seen to vary from positive to negative values and then return to positive again. The same characteristic will be seen for all of the models.

In the upper part of Fig. 6 is represented the coefficients C_T and C_Q, respectively. The solid curves are plotted through the observed points, whereas the dashed portion is derived from the corresponding portion of the lower curves. If the breaking away from a diagonal at very low speeds is to be accepted, it then follows that the curves representing the coefficients likewise break away from a horizontal straight line. It is also important to note that both coefficients which start as horizontal straight lines pass through a transitional stage and then as cavitation becomes more fully developed approach horizontal lines again.

Fig. 7 shows the corresponding results, both graphical and visual for propeller 414 with S = 0.35 and H = 1.92. The same characteristic shape of the curve will be observed,

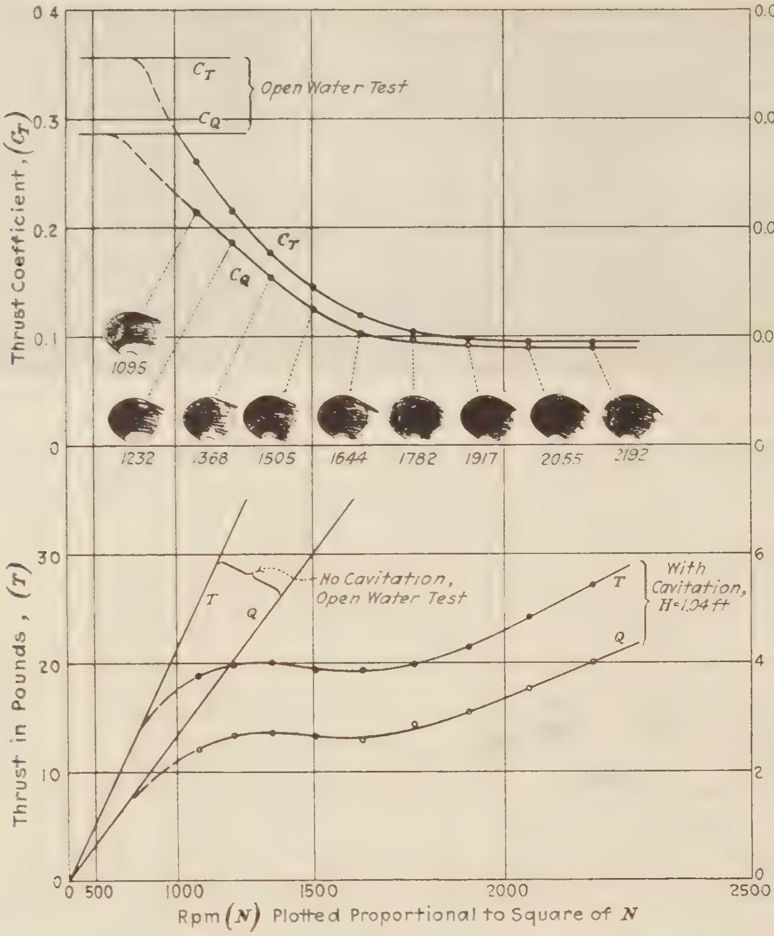


FIG. 6 CURVES OF T, Q, C_T AND C_Q VERSUS N FOR PROPELLER 1283-A

(Pressure H at hub, in excess of vapor pressure = 1.04 ft of water; for open-water test H is large. Slip ratio = 0.45. Black shading indicates laminar cavitation while dotted shading indicates burbling cavitation. Proportion of blade area covered by cavitation as indicated is probably correct within ±5 per cent. Cavitation as indicated is all on the back of the blade, i.e., the suction side.)

although the appearance of the cavitation is distinctly different.

The view shown in Fig. 8 was taken under rather unfavorable conditions, but for what it is worth shows the early stages of burbling cavitation. The light of the stroboscope is dim, and it is first necessary for the eye to become accustomed to it, and then the individual bubbles will be seen distinctly. However, in order to photograph these it requires a number of flashes and the resultant picture is vague. The apparent roughness is made up of rapidly moving bubbles. A photograph probably made by the light of a single electric spark presented by Cook (33) is reproduced by courtesy of the Institution of Naval Architects as Fig. 9. Shortly after the completion of these experiments better photographic apparatus was available, and excellent pictures could be obtained with the Edgerton stroboscope. Fig. 10 is an example showing individual bubbles and the beginning of tip vortices.

Fig. 11 shows the corresponding tests for propeller 1538 with slip S of 0.35 and H of 1.37 ft. Here the open-water test was not available to derive the straight portion of the curves, but the observed data show very clearly the general breaking away and, in particular, the distinct S shape of the curves of C_T and C_Q. It is also important to note on the sketches in Fig. 11, showing the visual appearance of the blades, the combination of burbling cavitation and the peculiar tip vortex which does not advance down the leading edge as in the case of propeller 1283-A. Unfortunately at the higher speeds the inherent structural weakness of this freak design led to mechanical failure of the blade following a bending of the tips. This caused the last two points to be displaced as indicated, and also prevented the open-water tests from being made.

Summing up the observations common to all of the models:

(a) By comparing the curves with the cavitation characteristics, it is evident that there is a correlation between the amount of cavitation and the departure of these low-pressure T-N and Q-N curves from the high-pressure T-N and Q-N curves taken from open-water characterization. This departure increases progressively as the amount of cavitation increases; until cavitation covers substantially the whole back of the blade, and from then on the departure maintains an approximately constant ratio to the high pressure T-N and Q-N curves.

(b) Since $\partial T/\partial N$ and $\partial Q/\partial N$ are the slopes of the T-N and Q-N curves, it is apparent that both $\partial T/\partial N$ and $\partial Q/\partial N$ are positive up to maximum values, pass through zero and become negative, reach minimum values, pass through zero again and become positive.

(c) It is clearly apparent that T and Q vary with N by some relation more complicated than varying as N^2; because, if T and Q varied directly as N^2, the T-N and Q-N curves would plot as straight lines when the abscissas are proportional to N^2, while the

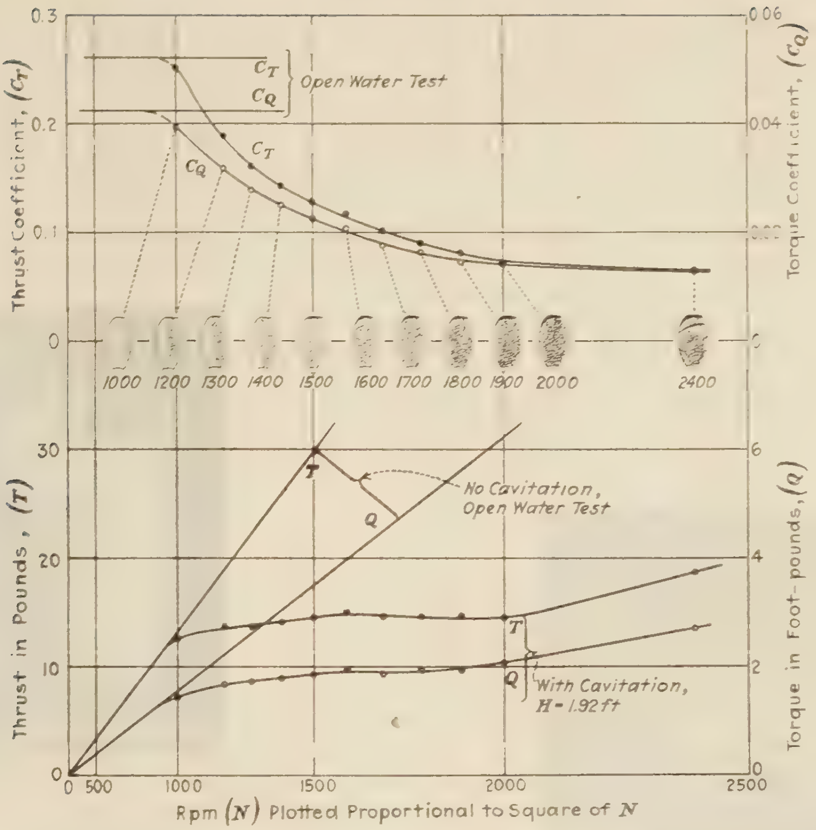


Fig. 7 Curves of T, Q, C_T and C_Q Versus N for Propeller 414

(Pressure H at hub, in excess of vapor pressure = 1.92 ft of water; for open-water test H is large. Slip ratio = 0.35. Black shading indicates laminar cavitation while dotted shading indicates burbling cavitation. Proportion of blade area covered by cavitation as indicated is probably correct within ±5 per cent. Cavitation as indicated is all on the back side of the blade, i.e., the suction side.)

actual curves under cavitating conditions are far from straight.

(*d*) An examination of the C_T and C_Q curves shows definitely and conclusively that those coefficients are not functions of S alone but are also functions of N. It is to be noted that C_T and C_Q seem to be approaching some constant value as N increases; and that probably, at very high values of N, and with cavitation covering the entire back of the blade, C_T and C_Q become constant for a given S and H without regard to further increases of N.

These are only the principal points as a more thorough discussion is reserved for part 5 of this paper.

G Experimental Determination of the T-H and Q-H Curves

In order to complete the investigation of the effect of the several variables upon the thrust and the torque, it remains to select a definite speed and slip ratio, and vary the pressure progressively over wide limits, at the same time noting the visual appearance of the back side of the blade. Figs. 12, 13 and 14 show the results for propellers 1283-*A*, 414, and 1538, respectively. Inasmuch as T and C_T are proportional to each other, and the same is true of Q and C_Q, when N is constant, the curves for T and Q have been omitted. The absolute values of thrust and torque do not contribute anything to clearness and the values of the coefficients are more readily comparable with the coefficients in previous curves.

A number of interesting deductions might be made from these figures, but it is desired to emphasize only two points at this time: (*a*) Examination of the curves shows clearly that, in the general case, thrust and torque coefficients are functions of H; and that $\partial T/\partial H$ and $\partial Q/\partial H$ do not become zero until relatively high pressures are reached. (*b*) Taylor (12, p. 91) has shown that, if it is desired to have comparable conditions on similar propellers of different sizes, the pressures on the two sizes must bear the relationship

$$P_{1/D} = p_{1/d}$$

where P_1 and p_1 = the pressures on the large and small propellers, respectively, and D and d = the diameters of the large and small propellers. Consequently if P_1 and p_1 are expressed in feet of fresh water, division by the corresponding diameter in feet gives pressures in propeller diameters of fresh water. If, instead of recording the pressure on a propeller in pounds per square inch or in feet of water, we record it in propeller diameters of fresh water we have a ready means of making a quick estimate of how the pressures on full-size propellers on sea-going ships compare with the pressures on models. For this reason an auxiliary scale was placed on the *T-H* and *Q-H* curves showing the pressures in excess of vapor pressure in propeller diameters of fresh water. This idea of using propeller diameters of fresh water as a unit of measurement greatly facilitates studying the pressure on full-size sea-going propellers, and such a study is presented in part 3.

3—PRESSURE ON SEA-GOING PROPELLERS

A Introduction

The *T-H* and *Q-H* curves of Figs. 12, 13, and 14 make it obvious that when there are high pressures on propellers a change of pressure has very little, if any, effect but that at low pressures a

slight change of pressure has a very great effect. There is no sharp dividing line between high pressures and low pressures but from a study of the curves it is reasonable to define "high pressures" as pressures at the hub above 20 propeller diameters of fresh water; and "low pressures" as pressures below 10 propeller diameters of fresh water leaving the region between as indeterminate.

The question then arises: Do actual sea-going propellers operate in the high-pressure, in the low-pressure, or in the indeterminate-pressure zone?

Since the pressure zones are so broad in terms of propeller diameters, since actual propellers always have at least full atmospheric pressure on them, and since sea-going propellers are usually large, we can ignore vapor pressure in the case of actual propellers. For example, if the vapor pressure equals 1 ft of fresh water and the propeller is 10 ft in diameter, then the vapor pressure equals only 0.1 propeller diameter of fresh water, which is negligible when we are considering pressure zones as broad as previously discussed.

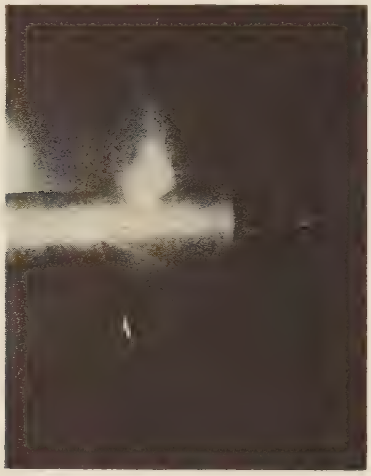


Fig. 8 Propeller 414 in Early Stages of Burbling Cavitation While Taking T-N and Q-N Data

(The roughness which appears on the back (suction) side of the blade is composed of individual bubbles which can be seen distinctly when the observer's eyes become accommodated to the light, but which cannot be photographed distinctly with the author's equipment. See Fig. 9.)

Hence, in order to answer our question a number of cases were chosen at random from merchant and naval surface ships and submarines. The following procedure was followed: (*a*) Hub submergence was taken from the plans for designed mean draft in sea water for surface vessels and draft aft for submarines. (*b*) This was converted to an equivalent pressure in feet of fresh water. (*c*) To this was added, as equivalent to the pressure of a standard atmosphere, 33.93 ft of fresh water. (*d*) This sum was divided by the propeller diameter in feet to obtain the pressure in propeller diameters of fresh water at the hub. (*e*) The vapor pressure was ignored for reasons previously stated.

Data for 66 surface ships and six submarines were examined by the foregoing procedure. The 66 surface ships included battleships, heavy cruisers, light cruisers, aircraft carriers, destroyers, a destroyer tender, an ammunition ship, a store ship, a transport, a repair ship, a submarine tender, an aircraft tender, a trawler, bay tugs, an ocean tug, a rescue tug, freighters, passenger ships of all classes, a training ship, and a passenger ferry.

The following is a summary of the results: The arithmetic mean of absolute pressures at the hub in terms of propeller diameters of fresh water was 3.7 and 6.0 for surface ships and submarines, respectively. The standard deviation from the mean was 0.69 and 0.61 for surface ships and submarines, respectively.

B Sea-Going Propellers Operate Under Low-Pressure Conditions

The data in the preceding section 3A make the conclusion inescapable that the propellers of sea-going vessels, including submarines running on the surface, operate under low-pressure conditions. Even the submarines would have to submerge about 100 ft before their propellers could be considered as working under high-pressure conditions.

Fig. 9 A Typical Example of Burbling Cavitation
(Courtesy of the Institution of Naval Architects, London.)

Fig. 10 Typical Burbling Cavitation and the Beginning of Cavities in Tip Vortices

(Taken with improved photographic equipment installed at the U. S. Experimental Model Basin after the completion of the author's experiments.)

The previous part of this paper (see particularly 2B) shows that two conditions, a high-pressure (large H) or a low rotary speed (small N), are required in order that the variations of propeller thrust (T) with N alone should follow the simple law that $T \propto N^2$; and that the thrust coefficient (C_T) should be a function of slip only; and likewise for torque and its coefficient.

This part of the paper, that is, part 3 demonstrates that, except in the case of deeply submerged submarines, one of these two conditions (large H) is not met in sea-going vessels. Consequently,

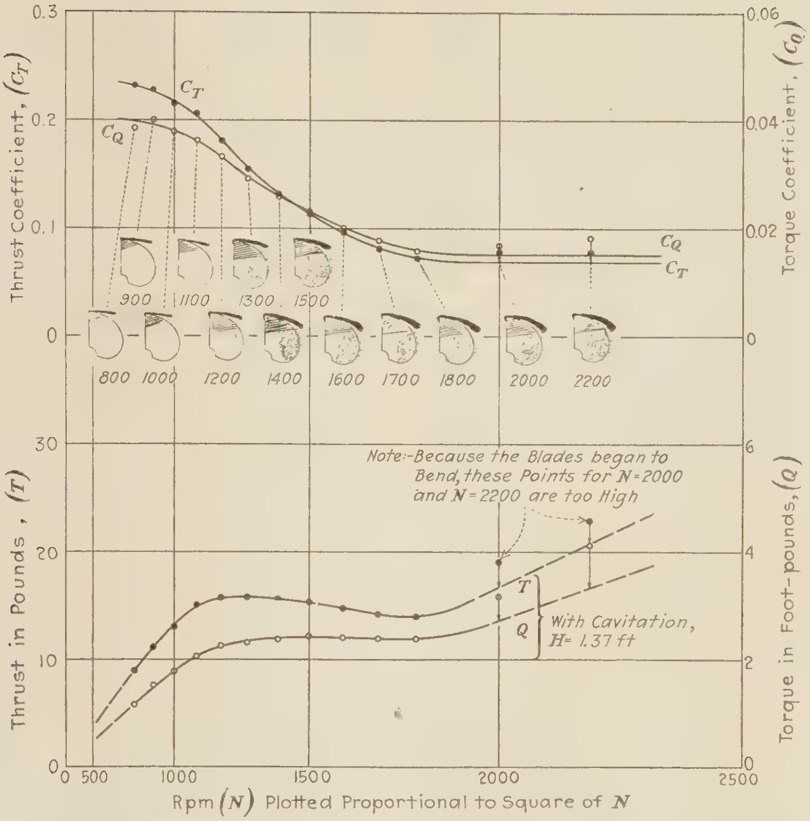


FIG. 11 CURVES OF T, Q, C_T, AND C_Q FOR PROPELLER 1538

(Pressure H at hub, in excess of vapor pressure = 1.37 ft of water. Slip ratio S = 0.35. Black shading indicates laminar cavitation while dotted shading indicates burbling cavitation. Proportion of blade area covered by cavitation as indicated is probably correct within ±5 per cent. Cavitation indicated is all on the back (suction) side of the blade. Line of the greatest thickness of blade runs from tip to root via midpoint of each section.)

unless the other condition (small N) is met, we must expect all the complications which arise from the fact that thrust and torque will no longer vary as N^2; and the thrust and torque coefficient will become functions of S, N, H instead of simple functions of S.

4—LOCATION OF FIRST BURBLING AND LAMINAR CAVITATION

A LOCALIZED LOW PRESSURE IS PREREQUISITE TO ANY CAVITATION

One of the best methods to eliminate cavitation would be to find the location at which it first occurs and eliminate it there.

A prerequisite to cavitation of any kind is a sufficiently low pressure. This can be demonstrated by experiments such as those reported in section 2G of this paper which show clearly that, all other factors remaining constant, cavitation does not begin until a sufficiently low pressure is reached, that cavitation does begin then, and that it can be crushed out by raising the pressure again. Ackeret's experiments (34) in connection with cavitation erosion show this even more clearly, and specifically show that the pressure required to prevent cavitation is almost exactly that required to prevent boiling.

Cavitation being a localized phenomenon, we may say that a localized pressure, low enough to permit boiling, is a prerequisite to cavitation. As the general static pressure is reduced near the suction face of a working propeller, it is obvious that the region which first reaches a localized pressure low enough to permit boiling is the region which had the lowest pressure before cavitation began. Consequently, if we knew the pressure distribution around a propeller blade, we could point to the region of lowest pressure and say: When cavitation begins it will begin there.

Pressure distribution can be, and has been, determined experimentally on airfoils. There are a number of theoretical methods for predicting with a fair degree of accuracy, the pressure distribution around an airfoil. The experimental method is obviously slow and tedious. The theoretical methods (35), for example the method of sources and sinks, are even more slow and tedious. Since our present object is simply to ascertain approximately where the regions of lowest pressure will occur, it seems possible that shorter and sufficiently accurate methods could be used to estimate this. Since burbling cavitation and laminar cavitation are distinctly different, the study of their sources will be made in separate sections of this paper.

B PROBLEM OF LOCATING FIRST BURBLING CAVITATION BY SHORT METHOD

Burbling cavitation on a blade moving relative to water appears when the pressure in any region has been reduced to approximately vapor pressure, and can be crushed out by increasing the pressure to slightly above vapor pressure, as is shown by the experiments of Ackeret (34). Therefore, the problem of determining the location of the first appearance of burbling cavitation resolves itself into this question: In what region on a propeller blade will the lowest pressure occur?

Since a short method is desired, a number of simplifications will be made, which *a priori* were believed to be justified and *a posteriori* were found to be justified. These simplifications are:

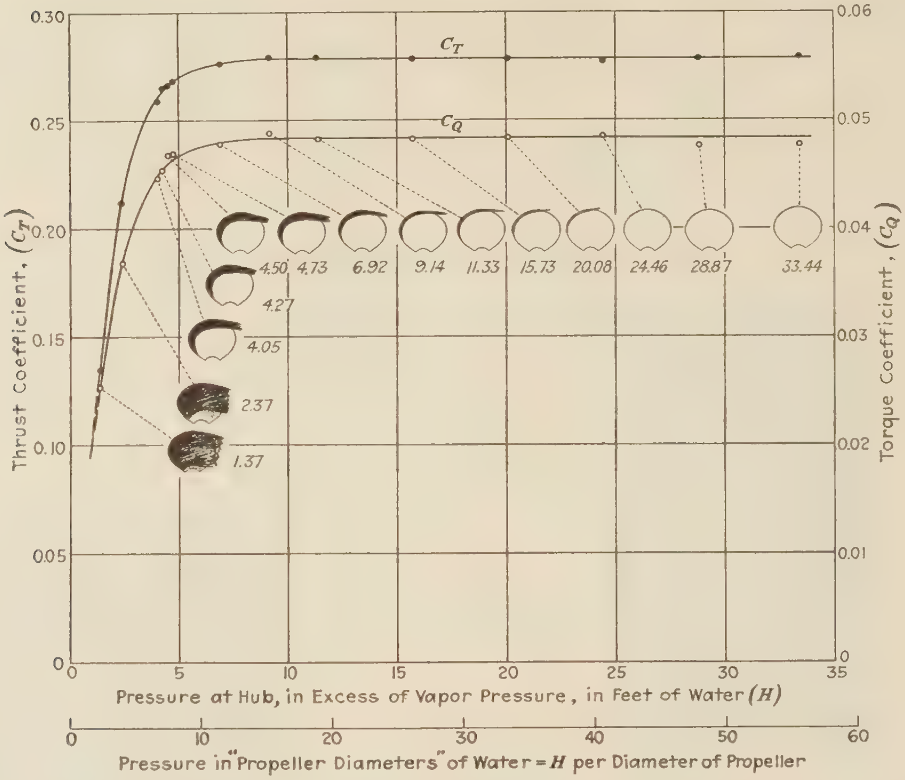


Fig. 12 Curves of C_T and C_Q Versus Pressure H at Hub Propeller 1283-A

(Speed = 1600 rpm. Slip ratio = 0.35. Black shading indicates laminar cavitation while dotted shading indicates burbling cavitation. Proportion of blade area covered by cavitation as indicated is probably correct within ±5 per cent. Cavitation indicated is all on the back (suction) side of the blade.)

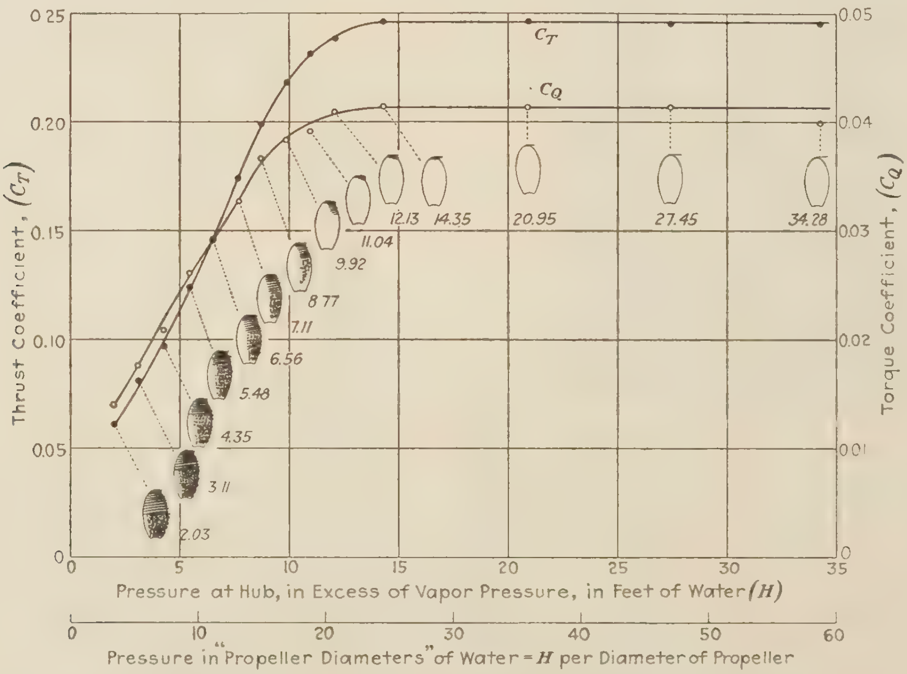


Fig. 13 Curves of C_T and C_Q Versus Pressure H at Hub for Propeller 414

(Speed = 1800 rpm. Slip ratio = 0.35. Black shading indicates laminar cavitation while dotted shading indicates burbling cavitation. Proportion of blade area covered by cavitation as indicated is probably correct within ±5 per cent. Cavitation as indicated is all on the back (suction) side of the blade. Small vortices, shown as streaks, originate at rough spots caused by corrosion after the T-N and Q-N test.)

(*a*) Only the case of uniform motion will be considered.

(*b*) Over the area considered—from near the leading edge to near the trailing edge—the velocity relative to the blade will be considered uniform. (Considering the usual curvature of blade sections and the usual angles of attack, this is a justifiable preliminary simplification and corresponds to that used by Prandtl (27) in deriving the pressure integral over the surface of an airfoil.)

(*c*) Over the area considered the stream lines will be considered approximately parallel to each other.

The following physical statements will be considered as correct for the present purpose:

(*a*) Liquid in which a body is submerged exerts a pressure on it.

(*b*) The pressure can be considered as being exerted by the liquid particles in immediate contact with the approximately stagnant boundary layer of liquid which clings to the body.

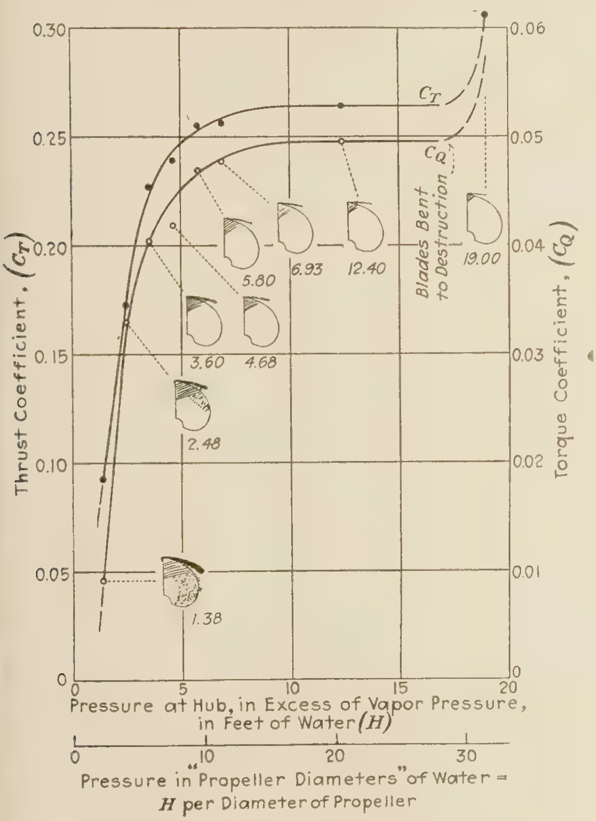


FIG. 14 CURVES OF C_T AND C_Q VERSUS PRESSURE H AT HUB FOR PROPELLER 1538

(Speed = 1600 rpm. Slip ratio = 0.35. Black shading indicates laminar cavitation while dotted shading indicates burbling cavitation. Proportion of blade area covered by cavitation as indicated is probably correct within ±5 per cent. Cavitation as indicated is all on the back (suction) side of the blade. Line of greatest thickness of blade runs from tip to root via midpoint of each section.)

(*c*) The particles outside those mentioned in (*b*) merely increase or decrease the pressure on the latter and, if the stream lines are approximately parallel, do not change the relative pressure exerted by a particle in contact with the body (or boundary layer) as it flows past the body.

(*d*) Consequently, if we determine the relative pressure exerted on a body by a particle which flows past it, but always in contact with it (or the boundary layer), we can determine the location of the lowest pressure.

(*e*) If a particle of liquid is being accelerated, a force is involved.

(*f*) In the case of a submerged propeller blade, the forces of gravity and cohesion can be ignored; therefore, the remaining force is a difference in pressure.

(*g*) A particle of liquid moving relative to but in contact with a submerged body has no relative velocity toward or away from that body, but may be accelerated relatively to the undisturbed fluid and this acceleration may be relatively toward or away from the body.

(*h*) If the acceleration is toward the body, it indicates that the pressure at the body is less than in the surrounding liquid; and vice versa.

C Solution of the Problem

For our analysis of this problem it will be necessary to refer to Fig. 15 and to use for this purpose only the following nomenclature, taking care not to confuse P, S, and N with the values of pressure, slip, and rpm used previously. The distinction between P as a pressure, and P as a point will in every case be perfectly obvious. In Fig. 15 which represents a general cross section of a propeller blade, let

P = a particle of fluid moving relative to but always in contact with the blade

R = radius of curvature of the blade at point P

P_0 = position of P when moving parallel to the direction of the motion of the blade in space, i.e., P_0 is the point of tangency where the curve of the back of the blade is tangent to the direction of motion W, and where $\theta = 0$

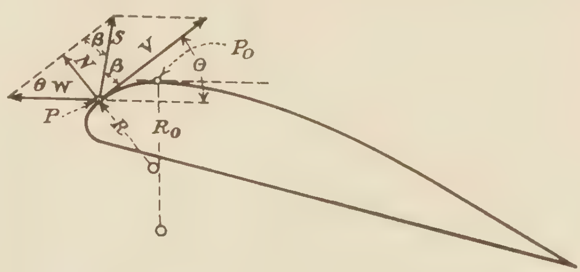


FIG. 15 DETERMINATION OF THE LOCATION OF POINT OF MINIMUM PRESSURE ON A PROPELLER BLADE

R_0 = radius of curvature of the blade at point P_0

W = velocity and direction of the blade in space, i.e., relative to the undisturbed fluid

V = velocity and direction of P relative to the blade. The direction must obviously be tangent to the blade. Note, from Fig. 15, that on the suction side of the blade V must always be greater than W, being compounded of W plus the circulation velocity

S = the velocity of P in space

N = component of S which is normal to the blade

θ = supplement of the angle between V and W

β = angle between S and V

Since V is always greater than W on the suction side, N must always lie between W and S; although, mathematically it would make no difference on which side of S, N lies; for in any case

$$N = S \sin \beta \qquad [19]$$

Now by a law of trigonometry

$$\frac{W}{\sin \beta} = \frac{S}{\sin \theta} \qquad [20]$$

Therefore

$$\sin \beta = \frac{W \sin \theta}{S} \qquad [21]$$

Hence

$$N = W \sin \theta \qquad [22]$$

The rate of change of N with respect to θ is

$$\frac{dN}{d\theta} = W \cos \theta \qquad [23]$$

Now

$$\frac{d\theta}{dt} = \frac{V}{R} \qquad [24]$$

Multiplying Equations [23] and [24] we get

$$\frac{dN}{d\theta} \times \frac{d\theta}{dt} = \frac{dN}{dt} = \frac{WV \cos \theta}{R} \qquad [25]$$

But dN/dt = the component of acceleration in space normal to the blade, so denoting this acceleration by A we have

$$A = \frac{WV \cos \theta}{R} \qquad [26]$$

and we have to consider how the value of A may vary with the position of the point P, when the shape of the blade, the angle of attack, and the speed W are given.

By our simplifying approximation (*b*), in section 4B of this paper, the speed V may be treated as a constant, except close to the edges of the blade; hence we may set

$$\frac{WV}{R_0} = C = \text{a const} \qquad [27]$$

and, letting $R = mR_0$ we may write Equation [26] in the form

$$A = C \frac{\cos \theta}{m} \qquad [28]$$

We exclude from consideration, as not occurring in marine propellers, those profiles in which the suction face is concave near the trailing edge; and consequently m is then always positive, varying from a small fraction near the leading edge of an airfoil section such as that illustrated by the figure, to $+ \infty$ at a place where the blade is flat. The angle θ is positive on the leading part of the blade, ahead of P_0, and negative on the trailing part, but always between + 90 deg and—90 deg so that $0 \gtreqless \cos \theta \gtreqless 1$; hence, A can never become negative.

"Ogival blades" are blades in which the profile of the back is a circular arc. These are the easiest to discuss for $m = 1$ everywhere, so that Equation [28] reduces to

$$A = C \cos \theta \qquad [29]$$

The value of A is evidently a maximum for $\theta = 0$, i.e., at the point of tangency P_0, and falls off in both directions so long as V remains constant.

Therefore, in the case of ogival blades burbling cavitation will ordinarily begin at the point of tangency, P_0. It is to be noted that the location of P_0 depends on the angle of attack, which is about half the slip angle due to the increase of water speed ahead of the propeller.[7] As the slip ratio increases, P_0 approaches and ultimately reaches the leading edge, where it can no longer be assumed that V = a constant; and in such case Equation [29] must be replaced by

$$A = \frac{WV}{R} \cos \theta \qquad [30]$$

As P (not P_0) approaches the leading edge, cos θ continues to decrease (slowly if the blade is thin); but if V increases rapidly, A may have another maximum which may be higher than the one at P_0. Now physical common sense and Bernoulli's theorem indicate that at high angles of attack[8] there will probably be a great local increase of V near the leading edge. Right at the leading edge $\cos \theta = 0$, so it is to be expected that if there is a maximum of A near the edge it will not be right at the edge although close to it; which is what actually happens, as will be indicated later.

Hence, in regard to ogival blades we may say:

(*a*) Under ordinary conditions of operation and at ordinary slip ratios there will be only one maximum value of A that it will be at the point of tangency P_0, and burbling cavitation will start there.

(*b*) At higher slip ratios there may be two maximum values of A: One at P_0, and the other sharply localized near the leading edge, and burbling cavitation may start independently from both places and finally spread and come together as W increases or the pressure is lowered.

(*c*) At high slip ratios, and angles of attack, P_0 will be at or so close to the leading edge that even if there were two maximum values of A at lower slip ratios the two would coalesce and burbling will start at or very near the leading edge.

Blades of "airfoil section," so far as they occur in marine propellers, have backs (suction faces) with a radius of curvature that is very small near the leading edge and increases continuously toward the trailing edge so that from P_0 forward $m < 1$ and from P aft to the trailing edge $m > 1$.

Near the trailing edge, and with such slips as occur in practice, θ is a rather small negative angle and cos θ is a little less than unity. As the point P moves forward cos θ passes through its maximum value of unity (i.e., $\cos \theta = 1$ at P_0) and then decreases more and more rapidly as P approaches the leading edge.

Since, in practice, between P_0 and the trailing edge $\cos \theta < 1$ and $m > 1$, the maximum value of A will not occur behind, but will occur at or forward of P_0.

Hence, we need to discuss only that portion of the blade from P_0 forward. Referring to Equation [28], it will be seen that the ratio ($\cos \theta/m$) is the controlling factor. Since both cos θ and m decrease as P moves forward from P_0, the value of the ratio ($\cos \theta/m$) will depend upon the respective rates of their decrease. Several practical cases may be cited:

(*a*) The ratio ($\cos \theta/m$) may vary at such a rate that as P moves forward A increases from its value at P_0 up to some greater value and then decreases; this is the usual case for airfoil sections, and in such a case burbling cavitation would begin forward of the point of tangency P_0.

(*b*) The ratio ($\cos \theta/m$) may vary at such a rate as P moves forward that A remains constant up to some point and then either increases or decreases. In the former case burbling cavitation would start so far forward of the point of tangency P_0 as to occur near the leading edge and in the latter case would start simultane-

[7] Aside from theoretical considerations, this increase of water speed ahead of the propeller can be proved by examination of the stream lines in the illustrations, particularly Fig. 10, of the paper "Photographs of the Flow Round a Model Screw Working in Water, Especially in the Vortex Ring State," by C. N. H. Lock and H. C. Townsend, *Philosophical Magazine and Journal of Science*, vol. 3, series 7, January-June, 1927, p. 224. In order to photograph the flow, Lock and Townsend sprayed into the water a mixture of xylene and carbon tetrachloride which has a density about equal to that of water but has a different refractive index.

[8] In the case of a marine propeller, an angle of attack in the order of 5 deg or greater must be considered high since it corresponds to a slip ratio so high that it is practically impossible for a propeller to operate satisfactorily. For example, if the angle of attack is 5 deg, the slip angle is about 10 deg, and if the pitch ratio is 1.0, the slip ratio will be 0.578, or nearly 58 per cent. Operating steadily at such a slip ratio is not practical because the maximum efficiency of propellers occurs at slip ratios of about 0.15 to 0.20.

ously over an area which is forward of the point of tangency.

(c) The ratio ($\cos\theta / m$) may vary at such a rate that there are two or more maxima, but this is unusual except in the case of high slip ratios where both maxima are so close to the leading edge that for practical purposes they coalesce, and as in the case of ogival blades at similar high angles of attack burbling cavitation would start in close proximity to, but not right at, the leading edge.

In view of the foregoing discussion it may be stated that under usual conditions burbling cavitation on an airfoil blade will start forward of the point of tangency P_0.

This discussion suggests that we should use the smallest radius of curvature of the back of the blade that can be used, while keeping out of burbling cavitation. Also, that we should so vary the radius of curvature that when burbling cavitation does occur it will occur simultaneously over the greatest possible area, for in such a case we shall have been exerting the maximum possible suction over the greatest possible area.

Equation [26] and Equation [30] indicate an explanation of the well-known fact that for a given width of blade the greater the thickness (and consequently the less the radius of curvature) the greater the lift (23, 36)—up to the point of burbling cavitation.

Since we were interested only in the reduction of pressure which causes burbling cavitation, the foregoing discussion was limited to the back of the blade, as under ordinary conditions the reduction of pressure occurs only on the back. However, at very small, or negative angles of attack reduction of pressure can occur on the face of the blade. The essential condition for reduction of pressure is that a particle P, flowing in contact with the blade, is being accelerated toward the blade. For such acceleration to occur the vector V shown in Fig. 15 must swing toward the blade as P moves toward the trailing edge. When the angle of attack is so low that the stagnation point[9] is on the back of the blade, the water which flows around the leading edge to the face of the blade must be accelerated toward the blade in that region and hence cause a reduction of pressure. Consequently, there may be a maximum reduction of pressure on the back of the blade and another on the face of the blade. This condition is shown later in Fig. 16 for angle of attack = −6 deg.

Although, in so far as cavitation is concerned, we are not concerned with increase of pressure, yet it should be pointed out that arguments similar to those which lead to the derivation of Equation [28] indicate an explanation of the well-known fact that the flat pressure face of a blade contributes a relatively small proportion to the thrust of a propeller (or lift of an airplane wing) in comparison to the thrust contributed by the suction side of the blade. At ordinary angles of attack the stagnation point is on the pressure side of the blade. The particles which flow in contact with the blade must have passed the immediate vicinity of the stagnation point. At that point the velocity component normal to and toward the blade is reduced to zero and consequently the acceleration normal to and away from the blade is a maximum, and there the highest pressure will occur. Thereafter, if the blade is flat, particles flowing in contact with it would have no acceleration normal to it and consequently would not increase the pressure. Such increase of pressure as does occur behind the stagnation point must be attributed to the slowing of the flow of water, and to particles not in contact with the blade which are still changing their velocity normal to the blade after the leading edge has passed. On this basis, if the pressure face of a blade is concave, a particle flowing in contact with it would be accelerated away from the blade during its passage across the blade and we could expect a greater pressure on the face; which does occur as matter of experimental fact.

[9] The stagnation point on the blade is where the stream of water divides, part flowing around the back and part flowing around the face.

D Experimental Verification

A number of ogival blades were tested at various angles of attack, and the pressure distributions are given in Report No. 499 of the Construction Department, Navy Yard, Washington, D. C., July 29, 1933. In every case there is a maximum suction very close to the point of tangency (where $\theta = 0$). The agreement is so close that any departure therefrom may well be an error of observation, considering that the measurements are taken at a number of points on the back of the blade and a curve faired through them. The only complication which arises is when the blades are at a high angle of attack (above 5 deg); this complication was indicated in the discussion of the Equation [30]. The complication is that there are two maxima. The first is due to flow around the sharp leading edge where R approaches 0. This gives a strictly localized and high degree of suction near the leading edge (within about 5 per cent of the chord length from the leading edge). The suction then decreases sharply, and thereafter rises to the normal maximum at the point of tangency (where $\theta = 0$).

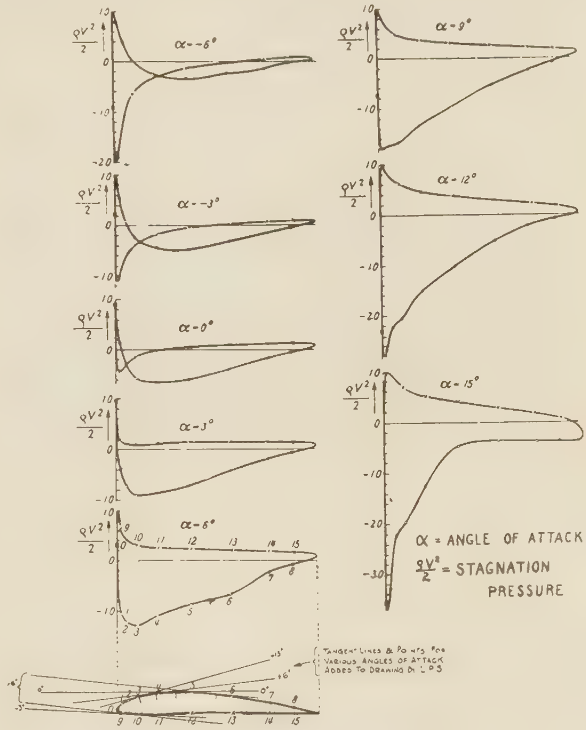


Fig. 16 Pressure-Distribution Curves for Middle Section of an Airfoil at Various Angles of Attack

(The curves reproduced here are from Prandtl (29). Notice that in every case the point of lowest pressure (maximum suction) is forward of the point of tangency, and that the more rapidly the radius of curvature is decreasing forward of the point of tangency, the further forward, relatively, is the point of lowest pressure. Notice particularly the case of $\alpha = -6$ deg where there is a point of lowest pressure on the upper side and the lower side of the wing.)

In the Report No. 34 of the Construction Department, Navy Yard, Washington, D. C., July 7, 1917, there are given the experimentally determined pressure distributions for an airfoil blade at a number of angles of attack and modified a number of times as to shape by bending the trailing edge. An examination of these shows the same general law to hold; the lowest pressure is near the point of tangency (where $\theta = 0$); or more generally forward of that if R is decreasing rapidly.

Prandtl (29) shows the experimentally determined pressure-distribution curves for the middle section of an airfoil at various

angles of attack. Those curves are reproduced in Fig. 16 with the addition of lines of tangency for the various angles of attack drawn on the sketch of the airfoil section. It will be seen that the lowest pressure occurs forward of the point of tangency (where $\theta = 0$) for each angle of attack and that R is decreasing rapidly forward of the point of tangency.

The tests of over 50 model propellers have been carried through cavitation. In every single case burbling began, as nearly as could be estimated, at the point of tangency, i.e., where $\theta = 0$, in accordance with the formula derived above; or somewhat forward of that point in the case of airfoil sections which have R decreasing toward the leading edge.

An important caution to observers should be noted at this point: The bubbles form, drift toward the trailing edge, enlarge, and collapse; therefore, the center of the area in which they are seen is well behind the point of initial formation. Obviously, the bubbles must begin forming at least as far forward as the leading edge of the area in which they are seen. At first glance, the leading edge of this area will not be seen as far forward as it really is because the illumination by a stroboscope is dim and the very small bubbles cannot be seen at their initial formation. Therefore, an observer should allow ample time for his eyes to become fully accommodated to the dim illumination of the stroboscope, concentrate attention on the leading edge of the burbling cavitation field in order to determine where burbling actually begins, and then raise and lower pressure to crush the cavities and then permit them to re-form. It will be well worth while for an observer to familiarize himself with the "still" reproductions of Mueller's (37) slow-motion pictures of burbling cavitation on a fixed blade in order to be certain of the details he should watch for on a rotating propeller.

E Usefulness of Equation [30]

As shown in the foregoing discussion, the acceleration dN/dt is the result of a pressure at the blade above or below that of the surrounding fluid. The total pressure at the blade is the pressure of the surrounding fluid plus or minus this acceleration pressure. Whether or not burbling occurs depends upon the total pressure at the blade. Hence, if the pressure in the surrounding liquid can be raised sufficiently, burbling cavitation can be crushed out. (See the author's variable-pressure experiments reported in section 2G of this paper.)

But the pressure on a marine propeller is limited by its practicable submergence. In the case of a surface ship the absolute pressure at the hub is limited to a fairly narrow range. As shown in part 3 of this paper, this pressure is about equal to that of a column of fresh water (3.7 ± 0.7) times the propeller diameter. Therefore, if the propeller is submerged as far as practicable, relief from burbling must be sought elsewhere. Equation [30] shows this can be done in three ways; viz.,

(*a*) Decrease W, which means decrease the speed of the propeller, particularly its rotary speed.

(*b*) Decrease V, which is compounded of W and the circulation velocity. Consequently, V can be reduced by decreasing either W or the speed of circulation, or both. The speed of circulation can be reduced by decreasing the angle of attack, i.e., the slip ratio in the case of a propeller.

(*c*) Decrease $(d\theta/dt)$. This can be done by increasing the radius of curvature of the blade, even though V remains constant. This increase of curvature can be attained by either widening or thinning the blade, or both.

As an important caution, Equation [30] indicates with a tolerable degree of accuracy where the point of lowest pressure occurs, and consequently where burbling cavitation starts. It is not intended to, and does not, predict the pressure distribution over the entire blade. The simplifying assumptions that from near the leading to near the trailing edge of a blade the velocities are uniform, and the stream lines parallel, are not nearly accurate enough for that. Consequently, while the formula may be used for estimating where burbling cavitation will first occur and what should be done to delay the occurrence, it should not be used for estimating actual pressure distribution more than a short distance in either direction from the point of maximum acceleration.

F A Vortex Is Prerequisite to Laminar Cavitation

A laminar cavity is a cavity stretched out in a long thin sheet or tube. A little consideration of the operation of the forces of hydrostatic and hydrodynamic pressures of liquids and gases, and the force of surface tension, will be convincing that a cavity in a liquid—in other words a bubble—must assume a form that is roughly spherical if the cavity is floating freely, and roughly hemispherical if the cavity is in contact with a solid unless some additional force is acting. A burbling cavitation field may have any form, but the individual bubbles will be of the forms indicated.

On the other hand, at the axis of a tubular eddy or vortex, the pressure falls below the static pressure in the body of the liquid outside because of the centrifugal forces of rotation, and if it falls as far as to the vapor pressure of the liquid, a tubular cavity is formed. The liquid tends to boil off into this open space, but any foam or spray that may result will also be rotating and will be thrown out against the walls of the cavity, frequently leaving an optically empty core with sharply defined walls. It is not apparent that an elongated cavity with this clear-cut appearance, characteristic of laminar cavitation, could originate from any other cause, and therefore the following argument will proceed on the assumption that the formation of a tubular vortex is prerequisite to the occurrence of laminar cavitation.

G Location of First Laminar Cavitation by Vortex Generators

If vortex formation is necessary for laminar cavitation, it may be expected that this cavitation will begin at such points on the blade as are most likely to generate strong vortices. Such parts of a blade will be called, for convenience, "vortex generators." The problem of locating the first laminar cavitation then resolves itself into locating vortex generators.

Ample theoretical and experimental authority for the immediately following discussion of vortex generators can be found in the works of Prandtl (30, 38) from which several quotations will be made. To simplify the discussion, the example of a single airplane wing will be discussed first, and the results applied to propeller blades later.

In the case of a finite wing the pressure differences between the top and bottom have "to disappear gradually toward the wing tips. On account of the greater pressure below the wing surface than above it, some air will flow from the bottom to the top around the wing tips. Therefore a sidewise current exists over most of the wing surface," directed outward on the lower side and inward on the upper side. "This causes a surface of discontinuity in the air leaving the wing, which is ultimately rolled up into two distinct vortices. According to the theorem of Helmholtz, these vortices always consist of the same air particles so that they leave the wing approximately with the wing's velocity through the air."

The term "bound vortex" has been reserved by many writers for the theoretical lifting vortex around and traveling with the wing. The term "free vortex" is generally applied to those actual vortices which trail astern from the wing tips, and it is a very appropriate name considering that the particles of fluid actually flow away from, or are left behind the wing.

But, desiring to bring out another idea, the author has coined the term "anchored vortex" in order to connote the idea that what-

ever the particles may be doing the form of the vortex remains anchored relative to the wing. The "sidewise current" mentioned previously makes the particles move in approximate helixes around the core of the vortex, making the vortex itself (when rendered visible by any means) take on the appearance of a twisted ribbon. Since new particles are continually being fed into the vortex, this helical motion around the core is necessary to the continued existence of an anchored vortex. If, instead of a helical motion, the particles had a motion in closed circuits around the core, the vortex could not possibly remain anchored. It would break away from the wing and drift astern, to be followed by a succession of other similar vortices; producing the phenomenon known as the Kármán Trail.

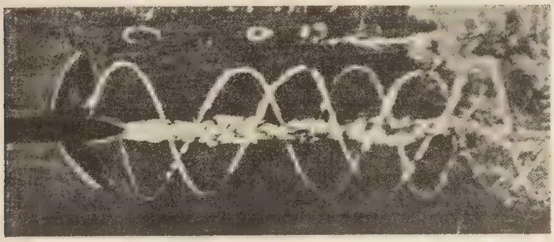


FIG. 17 ILLUSTRATING THE POSSIBILITY OF ROOT VORTICES AS WELL AS TIP VORTICES

The tip of a propeller blade corresponds to the tips of a wing. Therefore, it may be expected that the tip of a propeller blade will be the major vortex generator. If root vortices exist they are rarely apparent as cavities trailing astern, but the possibility that they may exist and can form cavities is indicated in Fig. 17, the illustration of which is credited to Flamm (49).

It may be readily understood that, by reason of the sidewise current, the tip vortex will start at some radius well short of the actual tip radius if the leading edge is curved aft, as is usual with propeller blades. This, in fact, does occur, and the straighter the leading edge the further toward the tip does the actual vortex start.

Obviously, any nick, roughness, or other irregularity on the blade will cause some disturbance of the flow over the surface of the blade. If the form of the irregularity is such as to produce a sidewise current the irregularity becomes a miniature vortex generator, and a miniature anchored vortex is formed. A group of such miniature anchored vortices is a laminar cavitation field.

(*H*) EXPERIMENTAL VERIFICATION BY DIRECT OBSERVATION

Typical examples of laminar-cavitation fields are indicated in Fig. 13 showing the cavitation characteristics of model propeller No. 414 after it had corroded and become roughened, and in Figs. 11 and 14 showing the cavitation characteristics of model propeller No. 1538 which had a weak leading edge easily subject to deformation. This latter propeller had a large anchored vortex originating almost exactly at the tip; on lesser radii it had a series of minute vortices. In every case the rough spots generating the minute vortices could be located by feeling with the finger nail or by observation with a magnifying glass. That there were separate minute vortices could be seen by lowering and raising the pressure so that the cavities formed and disappeared. With advanced stages of cavitation at very low pressures the edges of the thread-like tubular cavities were so close to each other that it was difficult to see clearly that they were separate; hence the impression was sometimes given that the cavitation field was a single thin sheet of one cavity. However, occasional clear glimpses showed that the thin sheet was composed of a series of thread-like tubes closely packed side by side, and slightly raising the pressure made it apparent that there really were a series of miniature anchored vortices forming the laminar-cavitation field.

It is much simpler to obtain direct observation of the large laminar cavities produced by tip vortices. The usual view of them is with the line of sight almost normal to the blade. With this view they give the appearance of thin sheet-like and perfectly smooth cavities lying on the back of the blade as shown in Fig. 5. There is no "ribbed" appearance to the sheet such as marks the separate minute vortices in a laminar-cavitation field. From the point of view described previously it is hard for an observer to see that the cavity really is the core of a vortex as long as he is looking through it at the blade, although he might infer this by looking at the "twisted-ribbon" shape, typical of an anchored vortex which trails away from each tip. But, if the observer moves so that his line of sight is practically tangent to the back of the blade, it is apparent that this "twisted-ribbon" or tubular cavity, shown in Fig. 18, forms the whole of the laminar cavity. Owing to the structure of the variable-pressure water tunnel it is difficult to get into position to obtain these latter views, which is probably the reason they were not observed before. The author would not have made observations from such a point had he not been led by *a priori* theoretical considerations to assume that a vortex is prerequisite to laminar cavitation, and then to try observing laminar cavities from all possible situations in order to find out if the assumption were true. The actual view with the eye is much clearer than the photograph. The stroboscopic light is so dim that the exposure of the photograph had to be about 10 revolutions, thus blurring the sharpness and distinctness of the edges of the cavities and not showing the actual helical motion of the water around the cavity which can be seen by an eye accustomed to the dim light.

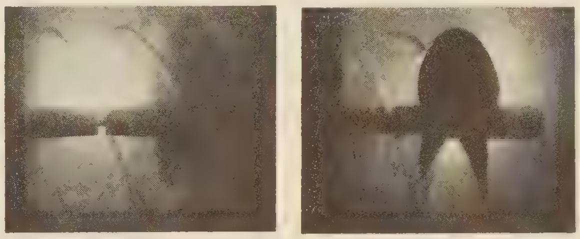


FIG. 18 PROPELLER 1283-*A* OPERATING AT 1600 RPM WITH 35 PER CENT SLIP

((*a*) Pressure at hub, in excess of vapor pressure = 8.66 ft of water. View is from such an angle that line of sight is approximately tangent to the back of one blade. The laminar cavity is not in contact with the back of the blade, but is separated therefrom by a thin wall of water. This is also true of (*b*) which was taken with a water pressure, in excess of vapor pressure, of 7.30 ft of water.)

The process of formation of a laminar cavity can be observed extraordinarily well by the following special procedure: Run the propeller at constant speed and slip as when taking the *T-H* and *Q-H* curves, start with full atmospheric pressure on the water surface, and pump down toward vacuum as rapidly as possible. The tip vortices, with their centers of low pressure have been there all along, of course, but cannot be seen because there is no appreciable difference in refractive index between the high- and low-pressure regions. As soon as cavity starts, there is a sharp difference in refractive index and the cavity is clearly visible. Following the procedure outlined, the observer sees the following successive phenomena: A series of small bubbles—like glass beads on a string—form along the axis of the vortex at a slight distance away from the blade. These bubbles enlarge and elongate until they appear like a string of sausages. With still further reduction of pressure, the ends of the bubbles coalesce and the typical laminar cavity results—a long tubular bubble, which has a cross section approximately circular while the diameter is small, and a

cross section becoming more and more elliptical as the diameter enlarges near the blade. The bubble with an elliptical cross section trails away from the blade like a twisted ribbon. As the laminar cavity collapses well astern of the propeller it goes through the reverse process: Its cross section becomes more circular, parts of the wall collapse giving it the appearance of sausages again, and finally the string-of-beads state is reached just before the final collapse. In the collapse of a very large laminar cavity these processes cannot all be seen so clearly, as the "string-of-sausages" state and string-of-beads state are more likely to be churned into turbulent foam owing to the larger forces involved.

In every case, however, as long as conditions permit clear vision and the line of sight is nearly tangent to the blade, it is apparent that the laminar cavity itself is not in contact with the blade; rather, it is always separated from the blade by a layer of water, sometimes a thin layer, but, nevertheless, a definite layer of

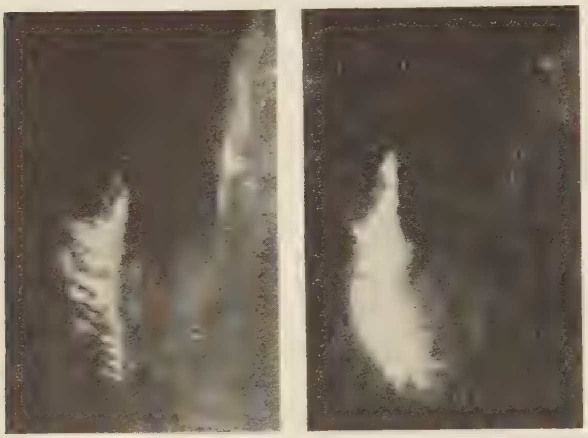


Fig. 19 Typical Examples of a Frothy Burbling Cavitation Field

(This cavitation field occurs when the water flows over a sharp leading edge in such a manner that no sidewise current exists, and consequently water cannot travel in approximately a helical path around a central axis, thereby forming an anchored vortex. These illustrations show face cavitation on the pressure side of the leading edge of a blade at low slip ratios. Illustrations published through the courtesy of the Institution of Naval Architects, London.)

water. An examination of Fig. 18 with a magnifying glass will show this. Some illustrations by Lerbs (40) of the cavitation around a stationary blade also show this effect. Study of the question will indicate that if, as assumed, a laminar cavity is at the core of a liquid vortex, then the cavity itself cannot possibly be in contact with the blade, because a vortex could not exist with one wall solid. This point is very important in explaining propeller action during cavitation; and will be discussed later in part 5 of this paper.

When flow around a sharp edge has no sidewise current, and consequently cannot produce an anchored vortex, a laminar cavity does not result. Instead, a burbling cavitation field is produced and is filled with frothy foam as shown in Fig. 19. This is typical of cavitation which occurs near the leading edge of the pressure face of a blade when the propeller is operating at a low slip ratio, or having some portion of the blade operating at very low or negative angle of attack. The hypotheses regarding vortex generators developed in the two preceding sections offer a practical explanation of the known facts that laminar cavitation can be reduced or delayed by (*a*) making the blade perfectly smooth and with easy curves, particularly near the leading edge; and (*b*) in particular by reducing the pitch near the blade tips, which, of course, reduces the sidewise current there and consequently reduces the strength of the anchored vortex at the tips.

I Experimental Verification for Both Kinds of Cavitation From Test Records of Numerous Propellers

In the foregoing sections there have been developed certain hypotheses regarding where burbling and laminar cavitation will begin. These hypotheses were developed by *a priori* reasoning from known physical laws and verified by intensive experimentation by the author on three types of propellers and by experimental evidence from known pressure distribution and vortex action on various types of airfoils.

Not being satisfied to stop at this point the author searched the records of the U. S. Experimental Model Basin for all propellers which had cavitation characteristics recorded. He examined these records to find if any one observation was contrary to his hypotheses, because one such observation would overthrow them. There was not one observation contrary to the hypotheses.

5—THE REASONS CAVITATION REDUCES THRUST AND TORQUE

A Rejected Explanations

An extensive study of the literature regarding marine propellers has revealed many writers and experimenters who state or prove that cavitation reduces thrust and torque below that which would be obtained with all other conditions the same except the existence of cavitation.

The favorite explanation of this phenomenon can be summarized in the words of Tutin (41):

"The thrust of a screw propeller is the resultant longitudinal component of the excess pressure on the face of the blades and the defect of pressure on the back. Both the pressure on the face and the suction on the back increase as the speed of advance and the revolutions are increased, but whereas an excess pressure may go on increasing indefinitely, the limit of suction at a given point is reached when the absolute pressure is reduced to zero, assuming for the moment an ideal fluid which does not evaporate, and which contains no occluded gases. Any further increase in speed and revolutions will produce no further increase in thrust at this point, and, will merely extend the boundaries of the region over which the pressure is zero.

"In the case of a fluid which evaporates, the limit of pressure will be reached when the absolute pressure is equal to the vapour pressure."

Other writers use similar explanations (15, 23, 42).

The implications of this explanation can be studied more readily if thrown into the form of mathematical equations. Remembering that the thrust is only one component of the total force, or lift, acting on an inclined plane moving through water, then

$$L = (h + p) - (h - s) \quad [31]$$

where L = lift on the inclined hydrofoil (or propeller blade); h = force on one whole face of the blade due to static pressure in excess of vapor pressure; p = force in excess of h due to kinetic action[10] on the entire pressure face; and s = amount by which force on the suction face is reduced below h by kinetic action.

It is further assumed (see last two sentences of the foregoing quotation from Tutin) that variations of h or s can carry $(h - s)$ down to a minimum of 0 when cavitation will occur; and that further variation in the same direction will leave $(h - s)$ constant. Hence according to the explanation:

When $(h - s) > 0$

$$\frac{\partial L}{\partial h} = 0 \quad [32]$$

[10] The term "kinetic action" is used purposely rather than "dynamic action" because it is more accurate and because of explanations in subsequent sections of this paper.

When $(h - s)$ is 0 and constant

$$\frac{\partial L}{\partial h} = 1 \qquad [33]$$

The implications of Equation [32] may be accepted, for it is a matter of general experimental fact that there is little or no variation of lift with pressure alone before cavitation occurs. The implications of Equation [33] may be accepted provisionally for certainly after cavitation occurs the lift decreases rapidly with pressure (although, for reasons which will not be discussed in this paper, it is doubted that the variation follows such a simple law as that indicated in Equation [33]).

The favorite explanation further assumes that, all other conditions (such as angle of attack, shape and size of blade) being constant

$$p = k_1v^2 \qquad [34]$$

and

$$s = k_2v^2 \qquad [35]$$

where k_1 and k_2 = constants for the particular conditions; and v = velocity relative to the undisturbed fluid.

Now, for a given propeller with a fixed pitch and operating at a fixed slip ratio we could substitute N (the rotary speed) for v and use other constants so that Equations [34] and [35] become

$$p = k_3N^2 \qquad [36]$$

and

$$s = k_4N^2 \qquad [37]$$

Substituting these values in Equation [31] we obtain

$$L = (h + k_3N^2) - (h - k_4N^2) \qquad [38]$$

and therefore when $(h - s) > 0$

$$\frac{\partial L}{\partial N} = (k_3 + k_4) \times 2N \qquad [39]$$

and when $(h - s)$ is 0 and constant

$$\frac{\partial L}{\partial N} = k_3 \times 2N \qquad [40]$$

The clear implications of Equations [39] and [40] are that both in and out of cavitation $\partial L/\partial N$ is always positive and greater than 0; although under cavitation conditions $\partial L/\partial N$ is smaller than under noncavitation conditions.

Since the forces producing thrust T and torque Q are merely components of L (corrected for skin friction) the implications of Equations [39] and [40] apply likewise to thrust and torque, so that the favorite explanation implies that both $\partial T/\partial N$ and $\partial Q/\partial N$ are always positive and greater than 0, although reduced under cavitating conditions.

It has been shown elsewhere (43) that if other things were equal the standard theories of propeller action all implied that

$$T = CN^m \qquad [41]$$

where T = thrust; C = a constant; N = revolutions per unit time; and m = a positive constant exponent, usually taken as 2, but always positive.

Therefore, the standard theories of propeller action imply that

$$\frac{\partial T}{\partial N} = mCN^{m-1} \qquad [42]$$

Equation [42] has the same form as Equations [39] and [40], which merely means that the favorite explanation of the action of propellers in cavitation follows the same form as the standard theories of propellers not in cavitation. The only difference is that the constant C would not be the same under cavitating conditions as the constant which is used under noncavitating conditions.

Without exception, every formally expressed theory the author has read or heard of contains these implications of Equations [39] and [40]. Notice that the value of $\partial L/\partial N$ being less in Equation [40] than in Equation [39], it is proper under the implications to state the frequently used expression "the thrust or torque decreased with increasing N due to cavitation" provided we keep in mind an implied qualifying clause necessary to make the statement precise, viz., "below the values which would have been obtained without cavitation."

Notice further that under the explanation so far given it would never be permissible to leave out that qualifying clause and boldly state: "the thrust and torque decreased with increasing N," for this would imply that $\partial T/\partial N$ and $\partial Q/\partial N$ could sometimes have zero and negative values. But the T-N and Q-N curves discussed in section 2F of this paper show that such zero and negative values do actually occur. Therefore, an explanation which implies that they cannot occur must contain an error.

It is highly improbable that this error in explanation could have persisted so long through the works of so many eminent writers had it not been for the almost universal habit of plotting propeller data in the form of thrust and torque coefficients (C_T and C_Q) over slip ratio S. Such coefficients, valuable as they are, often prevent a clear apprehension of just what variations in thrust and torque are occurring, and plotting them only over S is very effective in concealing variations which occur with changes of N. Similar difficulties can arise from the habit of plotting the so-called "polar curves" of coefficients with slip ratio or angle of attack written in as parameters. A further practice of plotting some dimensionless coefficient against Reynolds' numbers, while useful in summarizing great masses of data, is almost equally effective in making it difficult to apprehend the actual variations which are occurring in the important units of measurement. It is for these reasons that the author has made such extensive use of plotting actual values of thrust and torque, and of plotting them over actual values, not only of slip ratio but also of rotary speed and of pressure.

In spite of this, it is believed that a few writers have recognized that T and Q can actually decrease with increasing N, although recognition of that fact did not appear in their formal explanations. For example, both Saunders (11) and Baker (24) hint that the effects of cavitation are caused by a change in the "effective blade shape" or camber. Now the only way in which a cavity could change the camber of the blade would be to increase it, i.e., make the blade thicker. It has been shown repeatedly (28, 36) that increasing the camber (which involves increasing the thickness of the blade and decreasing the radius of curvature of its back) reduces efficiency but increases the lift. Therefore, the only change in effective camber which cavitation might make would be to increase it, and while this might be expected to reduce efficiency (which actually happens in cavitation), it could not reduce the thrust and torque (which also actually happens in cavitation). If it did anything, it would increase the lift and consequently thrust and torque. Walchner (4) even states that at the very beginning of a cavity on the back near the leading edge he can detect a slight increase of lift, although a decrease occurs later. Therefore the suggestion that a cavity causes a change in effective camber and that this causes a reduction in thrust and torque must be rejected as an explanation.

In oral discussions, the suggestion has been made to the author that boundary layer action might account for decreased lift with increased speed. Jacobs (44) shows that for an airfoil moving through air at low Reynolds' numbers the "point of separation"

between "dead air" in the boundary layer and the flowing air creeps forward from the trailing edge as the Reynolds number increases, and consequently reduces the maximum-lift coefficient below the value it would have had if such boundary-layer action had not occurred. He further shows that with still further increase of Reynolds' numbers, turbulence sets in, sweeps away part of the "dead air," and from then on the maximum-lift coefficient increases with increasing Reynolds' numbers. With the same wing operating in the same medium the changes of Reynolds' numbers would be directly proportional to changes of velocity and hence the changes in lift coefficient would vary with velocity in the same manner that they vary with Reynolds' numbers. It is not clear from Jacobs' paper that the lift itself ever actually decreased as velocity increased in the manner that thrust and torque decrease in the case of a cavitating propeller.

However, Prandtl (31) gives experimental evidence that the drag on a sphere or cylinder moving through a fluid increases with increasing velocity to a critical point, then decreases with further increased velocity, and finally increases again at a slower rate with still further increases of velocity. Prandtl explains this action satisfactorily by the boundary-layer theory. Now the shape of this drag-velocity curve is so similar to the shape of the *T-N* and *Q-N* curves that it seems plausible to explain the latter by the same boundary-layer theory—until the matter is examined more closely.

First, in the phenomenon described by Prandtl (31) the inflection in the drag-velocity curve, for a particular object and a particular fluid, occurs at a definite velocity without regard to pressure so long as that does not affect the kinematic viscosity of the fluid. In the case of the *T-N* and *Q-N* curves the inflection occurs at a different velocity for every different pressure, and with sufficient pressure it disappears entirely.

Second, the disturbance in the boundary layer always begins at the trailing edge and works forward with increasing velocity, until turbulence wipes it off in part. The disturbance due to cavitation never begins at the trailing edge and increasing velocities do not reduce it.

It should be noted most emphatically that all effects arising in the boundary layer are caused by loss of kinetic energy, i.e., decreased velocity with resulting stagnation and eventually turbulence. The remedies are either to suck the troublesome boundary layer into the solid, or to supply the boundary layer with additional kinetic energy, i.e., to increase its velocity.

On the other hand, the troubles due to cavitation are not due to stagnation or too low a velocity but always occur in connection with too high a velocity at too low a pressure. Cavitation results from causes other than and radically different from those that cause a turbulent boundary layer.

For these reasons we must reject the explanation that cavitation phenomena are due to action in the boundary layer.

In searching for another possible explanation let F_1 = total force due to absolute pressure on pressure side of blade; F_2 = total force due to absolute pressure on suction side of blade; and F_0 = total force which would exist on suction side of blade if F_2 were due only to vapor pressure.

Then Equations [31] and [38], which express the "favorite explanation" could be written as

$$L = F_1 - F_2 \qquad [43]$$

This statement is obviously true. Since erroneous results are obtained by using it, an examination of the assumptions regarding F_1 and F_2 is indicated. Referring to Equations [31], [34], and [36]

$$F_1 = (h + p) = (h + k_1v^2) = (h + k_3N^2) \qquad [44]$$

The assumptions of Equation [44] are so well substantiated by the experiments of many people that within any operating condition of a propeller they may be accepted as true.

Therefore, there must have been an error in the assumptions regarding F_2. These assumptions were:

First, F_2 is always positive. Second, F_2 has a lower limit equal to the total force which would exist on the suction side of the blade were that side acted upon only by vapor pressure. Let this lower limit be called F_0. Third, F_2 remains constant after reaching its lower limit.

Remove the restrictions and consider what might happen in the case of a propeller starting at a low rotary speed N, and then having N increased steadily until the propeller was in an advanced state of cavitation. The lift L would increase steadily with N until F_0 was reached, and then, because we have moved, the first and second restrictions would continue increasing in the same manner until F_2 had considerable negative value, i.e., the water on the back of the blade would be in a state of tension. Suddenly the water columns under tension would rupture, a cavity would form, the tension disappears, only vapor pressure remains, F_2 rises from its negative value to equal F_0, and consequently the lift decreases. Before the rupture and formation of cavities the lift had been

$$L = F_1 - (-F_2) \qquad [45]$$

After the rupture and formation of the cavity the lift becomes

$$L = F_1 - F_0 \qquad [46]$$

and since P_0 is constant for any fixed temperature L begins to increase again with increasing N, but at a lower rate.

For this explanation to be true (*a*) water must be able to transmit tension, and (*b*) it must actually be in a state of tension on the back of a blade shortly before cavitation occurs. It has been shown (16, 17, 18, 19, 20) that one of the definitely established foundations of fact and theory is that water, even when it contains dissolved salts and occluded gases, can transmit a tension of hundreds of pounds per square inch—which is more than ample to cover the case of any known marine propeller. In view of the fact and that this "tension hypothesis" can be used to explain every observed fact in the operation of propellers passing through cavitation, the hypothesis is very enticing.

But the question remains: Is water actually in a state of tension on the back of a blade shortly before cavitation sets in? Several facts make an affirmative answer highly improbable. In every experiment in which water was in a high state of tension the water was either stagnant or moving so very slowly that it must have been a case of pure potential flow. A small flaw, such as a bubble, in the tensile liquid spreads rapidly, almost instantaneously ruptures the liquid column, and relieves the tension. Now it is almost, if not quite, impossible that any propeller was ever operated in a field of pure potential flow, or in a region entirely free from passing bubbles.

However, the experiments of Ackeret (34) practically settle the question. He made a great number of observations on a fixed blade in the variable-pressure water tunnel at Göttingen. His reported observations indicate clearly that the pressure needed to prevent cavitation is proportional to the impact pressure of the undisturbed stream, or to the square of the speed, and that as the impact pressure is decreased by lowering the water speed the pressure needed to prevent cavitation approaches the zero (or the vapor pressure of water). These experiments indicating that there is no appreciable negative pressure, or tension by the water on the blade, taken in conjunction with the remarks in the preceding paragraph are sufficient to warrant the rejection of the "tension hypothesis."

B Formulation of the Problem

The discussion in the latter part of the preceding section makes it obvious that F_2, the total force due to the absolute pressure on the suction side of blade (see Equation [43]) is always positive, and consequently has a lower limit. But the third assumption, that after reaching its lower limit F_2 remains constant, cannot be true, because if it were the zero and negative values of $\partial T/\partial N$ and $\partial Q/\partial N$ found in the T-N and Q-N curves could not exist.

Consider Equation [43], and what happens to L as F_1 and F_2 vary with rotary speed N. Partially differentiating with respect to N gives

$$\frac{\partial L}{\partial N} = \frac{\partial F_1}{\partial N} - \frac{\partial F_2}{\partial N} \qquad [47]$$

We know as a matter of fact, confirmed by the experiments of many men, that $\partial F_1/\partial N$ is always positive. While F_2 always remains positive $\partial F_2/\partial N$ can take negative, zero, and positive values.

The following table shows what happens:

Condition	$\partial F_2/\partial N$	$\partial L/\partial N$
(a)	Negative	Positive and large
(b)	Zero	Positive and smaller
(c)	Positive and $= \partial F_1/\partial N$	Zero
(d)	Positive and $> \partial F_1/\partial N$	Negative
(e)	Positive and $< \partial F_1/\partial N$	Positive and small (between a and b)

Condition (a) represents the normal condition of a propeller operating under noncavitating conditions. Condition (b) represents the condition when F_2 has reached its lower limit, and according to the disproved favorite explanation, makes no further change. Since the forces producing thrust and torque are components of L we know from the T-N and Q-N curves that not only do conditions (a) and (b) occur, but also that (c) and (d) occur. Condition (c) occurs when the thrust and torque reach maximum values; condition (d) occurs when thrust and torque are decreasing with increasing N; condition (c) recurs when thrust and torque reach minimum values; condition (b) recurs as thrust and torque start to rise again; and condition (e) may or may not occur at all (the experimental evidence does not cover sufficient range to establish that).

The circulation, or vortex, theory explains condition (a) since it shows that normally the relative water velocity in the vicinity of the back of the blade is greater than the relative velocity in the undisturbed stream, and that this relative velocity near the back of the blade increases with increasing N. Consequently, the usual condition would be that $\partial F_2/\partial N$ would be negative.

The discussion in section 5A of this paper shows that F_2 has a lower limit, and consequently explains the first occurence of condition (b) when $\partial F_2/\partial N$ becomes zero.

We know by the T-N and Q-N curves that conditions (c) and (d) certainly can occur, that condition (e) possibly may occur, and that condition (b) certainly recurs. Therefore the problem which confronts us is: What physical actions account for these observed occurrences, i.e., what physical actions account for $\partial F_2/\partial N$ becoming positive and later passing through zero?

These odd occurrences happen only when cavitation can be observed to exist. Consequently, it can be asserted that cavitation is the cause. But how can cavitation cause these effects? That is the real problem. Since burbling cavitation and laminar cavitation are so different the answer to this question will be discussed in two separate sections following.

C Retarding Action and Impact Forces of Burbling Cavitation

If $\partial F_2/\partial N$ is ever to become zero or positive, then F_2, after reaching some minimum value must increase.

Many times, while observing the early stages of burbling cavitation with the Edgerton stroboscope, the author has been able to identify some particular bubble among the few then existing and notice that it moved comparatively slowly across the blade. Since the observation of the blade was by flashes of light lasting about five-millionths of a second per revolution, this meant that the bubble clung to the blade for several revolutions. Consequently, the bubble was not moving relatively to the blade with as high a velocity as the undisturbed water.

However, such evidence is not very satisfying as one often has to observe for hours before he can be sure he is identifying any one bubble, and in the advanced stages of burbling cavitation such certainty does not exist. Nevertheless, this evidence was useful for it led to a search of the literature of marine propulsion to discover whether or not anyone had ever made a slow-motion picture of burbling cavitation which would serve as confirmation of these visual observations and carry them on into the case of advanced cavitation.

Mueller (37) made such slow-motion pictures at the rate of 2000 exposures per second and in them the formation, growth, travel, and collapse of individual bubbles can be traced very accurately. When the water velocity in the undisturbed stream was 6.5 meters per second the velocity of the bubbles was 4.5 meters per second. This is definite confirmation of the observation that the velocity of the bubbles is less than the velocity of the undisturbed water, and consequently still less than the velocity which would exist on the back of the blade were there no bubbles. It cannot be stated, or even expected, that the water flowing between the bubbles is as slow as the bubbles. But considering fluid viscosity, it can be stated that a mass of such slow-moving bubbles on or near the back of a blade would exert a retarding action on the water flowing in contact with that blade. When the velocity of a stream of water is retarded, its static pressure rises. Consequently, the retarding action of the bubbles would cause an increase of F_2.

It can easily be observed that many, if not most, of the bubbles collapse before passing the trailing edge of the blade. As a matter of theory, the collapse of a bubble should produce a water hammer and momentarily raise the pressure in the immediately surrounding fluid. As a matter of experimental fact, Föttinger points out that it does (45): "After short intervals of flow, the individual cavities collapsed with hard cracking in parts, which shook the entire tube, and even caused intensive increases in the pressure readings on a spring manometer connected with the nozzle. (Several atmospheres.)"

The experiments of Ackeret (2) are even more definite. Ackeret made direct pressure measurements of the individual impacts due to collapsing bubbles. He used a piezoelectric arrangement. A piston of 2 mm diameter transmits the pressure to the quartz (of the piezoelectric apparatus), increases the electric charge on this, and makes a record on an oscillograph. Each time a bubble collapsed over the piston the pressure rose from 10 to 15 fold.

With pressure increases of such an order it is obvious that when bubbles are collapsing in rapid succession in the area of a burbling cavitation field that the average pressure in that area will exceed considerably the pressure in water at similar velocities but without the collapsing bubbles. This increase in pressure would of necessity raise F_2 above its minimum.

We can now understand how, as the burbling cavitation starts and spreads over the blade, the value of $\partial F_2/\partial N$ changes from its original negative values through zero, to positive—and further that when burbling cavitation had covered the complete back of

the blade it could exert little, if any, additional effect (as the additional bubbles would then be collapsing well astern) and $\partial F_2/\partial N$ would approach zero a second time.

There is no *a priori* reason for asserting that $\partial F_2/\partial N$ would ever equal or exceed $\partial F_1/\partial N$; but from the *a posteriori* reasons that experiments show that in advanced stages of cavitation $\partial L/\partial N$ becomes zero and negative we know that this is true.

Therefore, the theory is stated that: Burbling cavitation reduces thrust and torque because its retarding action on the flow over the back and the impact forces of collapsing bubbles on the back increase the pressure on the back of the blade faster than increased revolutions increase pressure on the face of the blade.

D Laminar Cavitation Increases Total Pressure by Vortex Action

It is a well-known fact that, due to surface tension, the pressure inside a bubble, or cavity, in a fluid is slightly in excess of the pressure immediately outside; but, since this excess pressure varies inversely as the radius of the cavity it may be asserted that the pressure in a laminar cavity cannot be sensibly different from vapor pressure.

Consequently, if the laminar cavity were in contact with the back of a propeller blade, the pressure on that area would equal vapor pressure; and, when the cavity covered the entire back of the blade, F_2 would be at its minimum value and remain constant with further increases of N. In short (see discussion in section 5*B*), $\partial L/\partial N$ could never become zero or negative in the case of laminar cavitation. But the *T-N* and *Q-N* curves show that even in completely laminar cavitation $\partial T/\partial N$ and $\partial Q/\partial N$, and therefore $\partial L/\partial N$ do in fact reach zero and negative values. Since these phenomena could not occur if the laminar cavity were in contact with the back of the blade, it may be asserted that a laminar cavity is not in contact with the back of a blade.

Sections 4F to 4I, inclusive, presented theoretical and experimental evidence to show that a laminar cavity is the center of a vortex, and that the cavity itself is not in contact with the blade but is separated therefrom by the liquid wall of the vortex. The mathematical theories of fluid motion are not yet far enough advanced to calculate with precision the pressure distribution around a vortex as complicated as that originating, for example, at a propeller tip; particularly, with the complication which arises when the central region of the vortex is a vapor-filled bubble so that we are dealing with two fluids (see section 1D).

A mathematical solution has been obtained, however, for the pressure distribution around a rectilinear vortex in a single fluid. A study of this solution will enable us to predict with sufficient qualitative accuracy the effects which the more complicated vortex will have on a propeller when laminar cavitation results. The mathematical solution for the pressure distribution in the neighborhood of a rectilinear vortex in a single fluid is given by Prandtl (39) as

$$p = P_0 - \frac{\rho\Gamma^2}{8\pi^2 r^2} \qquad [48]$$

where p = pressure at any finite point; P_0 = pressure at "infinity;" r = radius of p from center of vortex; Γ = circulation around vortex; and ρ = density of fluid. Thus, the pressure increases radially outward from the center of the vortex, although the rate of increase becomes very small at a short distance from the center.

Qualitatively, at least, this statement must be true for our more complicated vortex surrounding a laminar cavity. Note, however, that since the pressure throughout the cavity must be sensibly equal to vapor pressure, the pressure rise in the liquid vortex must begin with the walls of the cavity. In other words, measurement of r begins at the walls of the cavity and not at the mathematical axis of the cavity.

To understand what happens consider a propeller such as No. 1283-*A* (see sections 2D and 2G) being run at constant revolutions and slip ratio, while the pressure head on the propeller is being varied as when *T-H* and *Q-H* curves in Fig. 12 were obtained. An anchored vortex practically paralleling the leading edge extends from near the root of the blade to the tip and then trails astern. The vortex can be rendered visible as described in section 4H of this paper.

Before cavitation starts the axis of this vortex is merely a mathematical line of low pressure about which the water particles are traveling in more or less helical paths. For a short distance from this line the pressure rises rather rapidly, and thereafter much more slowly until it would hardly affect pressure gradients at a short distance from the axis. Consequently, the vortex would not sensibly affect the region of greatest suction (approximately at the point of tangency, sections 4B, 4C, and 4D).

After cavitation starts the line of low pressure becomes a tube of low pressure, which is the long tubular cavity forming laminar cavitation. The pressure increase starts from the walls of this cavity. Consequently, as the cross-sectional area of the cavity expands (with constant vapor pressure inside) and spreads over the back of the blade, the walls of the cavity carry with them their region of higher pressures and disturb the pressure gradients which otherwise would have permitted regions of low pressure on the back of the blade. The spreading of the relatively higher pressure which surrounds a vortex over a greater area of the back of the blade would increase the total force F_2 on the back and hence decrease the lift L.

Since laminar cavitation spreads with increase of rotary speed N as well as with decrease of pressure in excess of vapor pressure H, we can expect (and actually observe as shown in Fig. 4) effects which follow an increasing N to be similar to those which follow a decreasing H.

Using the same notation as in the preceding sections, as laminar cavitation spreads over the back of the blade, the value of $\partial F_2/\partial N$ changes from its original negative values through zero, to positive and, when laminar cavitation covers the complete back of the blade, it would exert little, if any, additional effect and therefore $\partial F_2/\partial N$ approaches zero a second time.

As in the case of burbling cavitation, there is no *a priori* reason in the case of laminar cavitation for asserting that $\partial F_2/\partial N$ would ever equal or exceed $\partial F_1/\partial N$. However, from the *a posteriori* reasons experiments show that in advanced stages of cavitation $\partial L/\partial N$ becomes zero and negative we know that this is true.

Thus the theory is stated that: Laminar cavitation reduces thrust and torque because the laminar cavity is the center of a vortex surrounded by a region of relatively higher pressure, and as this cavity spreads over, but not in contact with, a blade, it carries this region of relatively higher pressure with it, disturbing the usual pressure gradients, and increasing the total force on that side of the blade.

E Reasons Sufficient to Explain Why Cavitation Reduces Thrust and Torque

In section 2F it was shown that in the case of a given propeller, operating at a constant slip and under a constant pressure, as N increases T and Q increase at first, then decrease, and finally increase again more slowly. Plotting the data gives a double inflection to the *T-N* and *Q-N* curves. These data are experimental facts. They require an explanation.

There have been examined, suggested, and conceivable explanations; and one by one reasons have been found for rejecting them, until the writer developed theories of his own to cover the cases of burbling and of laminar cavitation. These theories explain the

facts by concepts whose perceptual equivalents have been actually disclosed and since "we are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances" it is believed that these theories not only give sufficient reasons to explain why cavitation reduces thrust and torque, but also that they comply fully with Isaac Newton's "Rules of Reasoning" (46) and Pearson's "fundamental canon of the scientific method" (47).

F Reasons Explain the Negligible Effect of Face Cavitation

It has been observed repeatedly that face cavitation, i.e., cavitation on the pressure side of propeller blades, has little or no perceptible effect on propeller performance (48). In view of the marked effect of cavitation on the suction side of the blade, this seems astonishing until we consider the explanations. It was shown that both burbling and laminar cavitation increased the total absolute force on the side of the blade on which they occurred. Therefore, on the pressure side of a blade, as the pressure declined in any area to a degree permitting cavitation, the harmful effect on lift would be more or less offset by the increased forces caused by cavitation. In view of this, and in view of the fact that face cavitation usually occurs in only relatively small areas it is easy to understand why the effects of face cavitation on propeller performance are negligible. Thus the same theories which explain why cavitation on the suction side reduces lift, also explain why cavitation on the pressure side has very little effect on lift.

Acknowledgment

The author is indebted to Dr. Edgar Buckingham, U. S. Bureau of Standards, for the patient and constructive criticism he advanced during many long hours of friendly argument regarding the points in this paper.

Bibliography

1 "The Logic of Modern Physics," by P. W. Bridgman, The Macmillan Company, New York, N. Y., 1927.

2 "Cavitation and Erosion" (German), by J. Ackeret, Hydromechanische Probleme des Schiffsantriebs, Hamburg, Germany, 1932, pp. 227–240.

3 "Experiments on a Few Typical Phenomena of Cavitation" (German), by H. Föttinger, Hydromechanische Probleme des Schiffsantriebs, Hamburg, Germany, 1932.

4 "Blade Tests in Cavitation" (German), by O. Walchner, Hydromechanische Probleme des Schiffsantriebs, Hamburg, Germany, 1932, pp. 256–267.

5 "Corrosion Caused by Cavitation in a Diffuser" (German), by H. Schröter, Hydromechanische Probleme des Schiffsantriebs, Hamburg, Germany, 1932.

6 "Cavitation and Corrosion" (German), by K. Springorurn, Hydromechanische Probleme des Schiffsantriebs, Hamburg, Germany, 1932.

7 "Physics," by Oliver Lodge, Encyclopaedia Britannica, 14th edition, vol. 17, p. 881.

8 "Smithsonian Physical Tables," Frederick E. Fowle, 8th revised edition, Washington, D. C., 1933, Tables 106 and 708.

9 Ibid., Tables 119, 208, 170 and 193.

10 "The Prediction of Speed and Power of Ships by Methods in Use at the United States Experimental Model Basin," by H. E. Saunders, U. S. Navy Department, Construction and Repair Bulletin No. 7, Washington, D. C., 1933, p. 52, printed by Government Printing Office, on sale by Superintendent of Documents.

11 Ibid., p. 51.

12 "The Speed and Power of Ships," by D. W. Taylor, Ransdell Press, Washington, D. C., 1933.

13 Ibid., p. 96.

14 Ibid., Fig. 225, p. 112.

15 Ibid., p. 38.

16 "Optics," by Isaac Newton, 4th edition, printed 1730, reprinted in 1931, New York, N. Y.

17 "On the Ascent of Sap," by H. H. Dixon and J. Joly, Philosophical Transactions of the Royal Society of London, series B, vol. 186, 1895, part 1, pp. 563–576.

18 "Transpiration and the Ascent of Sap," by H. H. Dixon, The Macmillan Company, New York and London, 1914.

19 "The Askenasy Demonstration of Traction Transmitted Through Liquid Water," by B. E. Livingston and G. Lubin, *Science*, new series, vol. 65, April 15, 1927, pp. 376–379.

20 "The Askenasy Experiment to Demonstrate Negative Pressure and the Transmission of Traction in Water," by B. E. Livingston, privately printed, December, 1928.

21 "Systematic Tests With Model Propellers," by K. Schaffran, *Werft, Reederei, Hafen*, vol. 15, no. 29, November, 1934, p. 325.

22 "Ship Design, Resistance, and Screw Propulsion," by G. S. Baker, Charles Birchall & Sons, Ltd., Liverpool, 1933, vol. 2, "The Marine Screw Propeller and Propulsion of Ships."

23 Ibid., pp. 30 and 155.

24 Ibid., p. 155.

25 "Dimensional Analysis of Model Propeller Tests," by E. Buckingham, Journal of the American Society of Naval Engineers, vol. 48, May, 1936, pp. 147–198.

26 "Applied Hydro- and Aeromechanics," by L. Prandtl and O. G. Tietjens, Lectures of Prandtl reported by Tietjens, translated from German by J. P. DenHartog, Engineering Societies Monographs, McGraw-Hill Book Company, New York, N. Y., first edition.

27 Ibid., p. 160.

28 Ibid., p. 151.

29 Ibid., p. 157, Fig. 102.

30 Ibid., particularly chapter 6, section C, "Three-Dimensional Airfoil Theory," p. 185ff.

31 Ibid., pp. 98 and 99.

32 "The Variable Pressure Water Tunnel of the U. S. Experimental Model Basin," by H. E. Saunders, Transactions of the Society of Naval Architects and Marine Engineers, vol. 38, 1930, pp. 205–217.

33 Discussion of "Cavitation Experiments on a Model Propeller," by S. S. Cook, Transactions of the Institution of Naval Architects, vol. 74, 1932, pp. 165–185.

34 "Experimental and Theoretical Investigation on Cavitation" (German), by J. Ackeret, *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 1, January and February, 1930, p. 1 and p. 63.

35 "Report of the Committee on Hydromechanics," by H. L. Dryden, F. D. Murnaghan, and H. Bateman, National Research Council, Bulletin No. 84, Washington, D. C., 1932, p. 7.

36 "Characteristics of Propeller Sections Tested in the Variable Density Tunnel," by E. N. Jacobs, National Advisory Committee for Aeronautics Annual Report, 1927, Report No. 259, pp. 1–2.

37 "Slow Motion Film of a Cavitating Airfoil" (German), by H. Mueller, Hydromechanische Probleme des Schiffsantriebs, Hamburg, Germany, 1932, pp. 311–314.

38 "Fundamentals of Hydro- and Aeromechanics," by L. Prandtl and O. G. Tietjens, Lectures of Prandtl reported by Tietjens, translated from the German by L. Rosenhead, Engineering Societies Monographs, McGraw-Hill Book Company, first edition, 1934, p. 189.

39 Ibid., p. 214.

40 "Photographs of Cavitation in the Boundary Eddies of an Airfoil" (German), by H. Lerbs, *Werft, Reederei, Hafen*, vol. 13, January 1, 1932, p. 1.

41 "A Theoretical Investigation of the Phenomenon of Cavitation in Screw Propellers," by J. Tutin, *Philosophical Magazine and Journal of Science*, series 7, vol. 4, July, 1927, pp. 17–28.

42 "Resistance of Fluids" (French), by H. Bouasse, Delagrave, Paris, 1928, Fig. 195, p. 361.

43 "Marine Propeller Phenomena," by L. P. Smith, D.Sc. Thesis, American University, Washington, D. C., chapter 2, section 5.

44 "Aerodynamics of Wing Sections for Airplanes," E. N. Jacobs, *Society of Automotive Engineers Journal*, vol. 34, March, 1934, pp. 82–91.

45 "Progress of the Theory of Flow in Mechanical Engineering and Shipbuilding" (German), by H. Föttinger, Jahrbuch der Schiffbautechnischen Gesellshaft, vol. 25, 1924, pp. 295–344. Translation by M. C. Roemer, U. S. Experimental Model Basin.

46 "The Mathematical Principles of Natural Philosophy," by Isaac Newton, (Latin 1686), Translated into English by Andrew Motte in 1729. Published by Daniel Adee, New York, 1846.

47 "The Grammar of Science," by K. Pearson, London, 1900, pp. 298–299.

48 "Propeller Cavitation Studies," by C. O. Kell, Transactions of the Institution of Naval Architects, vol. 76, 1934, pp. 367–379, particularly p. 369.

49 "The Elements of the Lanchester-Prandtl Theory of Airplane Lift and Drag," *Engineering*, vol. 117, January–June, 1924, pp. 1, 35, 100, 169, 258.

Metallurgical Aspects of Hot and Cold Strip for Deep-Drawing Requirements

By J. E. Angle,[1] Gary, Ind., and W. F. McGarrity,[2] Pittsburgh, Pa.

It is the purpose of this paper to give a brief but specific discussion of the basic underlying metallurgical features of hot and cold strip. Recrystallization in hot rolling, effects of finishing temperatures on the grain structure and properties of hot strip, effects of hot and cold coiling, and information regarding forming and drawing qualities of hot strip are discussed. Operating features and limitations are pointed out. Cold-strip processing, together with physical properties and other requirements for deep-drawing work are outlined.

PROBABLY the most important advancement in the sheet industry in this century is the development of the broad-strip rolling process. Compared with the arduous task of making sheets and tin plate by the older hand method, these new mills, with much less effort, can roll steel of considerably higher quality. This method of sheet manufacture has advanced the economical production of the streamlined, all-steel automobile.

By reason of the superior drawing qualities resulting from the process, articles are being made from one piece of steel which formerly were welded or fabricated, and the high finish which can be secured with cold reduction has made it possible to plate steel with nickel or chromium without buffing or polishing. Where half a dozen coats of paint formerly were required on automobiles and furniture, one or two coats are now sufficient.

Many new problems, however, have presented themselves to the strip manufacturer, and particularly to the metallurgist. While there is nothing particularly abstruse or profound about hot- and cold-strip metallurgy in its usual aspects, it may seem somewhat foreign to the steel-mill metallurgist who is engaged in other fields. The purpose of this paper is to give a brief discussion of the basic underlying metallurgical features of hot and cold strip.

At present, deep drawing hot-rolled strip and cold-rolled strip are made almost exclusively from open-hearth rimmed steel ranging from 0.03 to 0.10 per cent carbon, 0.20 to 0.50 per cent manganese, with phosphorus and sulphur as low as possible, and with only a trace of silicon. Good open-hearth practice is of the utmost importance in successfully meeting the exacting ductility requirements that the design of modern deep stampings demands. Cleanliness and freedom from harmful segregation and laminations are vital, as dirt stringers and inclusions in such thin material will often cause fractures during drawing.

The analysis of the steel will vary for different jobs. For large deep stampings, it is usually desirable to ship as soft a sheet as possible to avoid wrinkling in the dies, and, in such cases, the carbon and manganese are held to the lower side of the range. Other stampings are best accomplished with a tough, fine ferritic-grain steel, in which case the carbon and manganese are specified toward the high side of the range. Regardless of use, however, it is always desirable to hold phosphorus and sulphur to a minimum for the sake of ductility.

Recrystallization in Hot Rolling

The microstructure of some of the material produced on a continuous hot-strip mill resembles that pictured in Fig. 1. Especially is this the case when the material is relatively light in gage (0.093 gage) and when it has been finished at a temperature just under the A_3 point. It is not a particularly good structure, and disregarding its possible effect on the subsequent cold-rolled and annealed grain structure, if the material is for cold rolling, it is definitely not as desirable as an even, well homogenized structure.

Such a structure is caused primarily by two factors, which are, segregation, and the amount of reduction the material receives at a certain temperature in the last stand. There are others to be sure, and these have some effect on the finished product, but they do not seem to be as important, and cannot be so well measured, as the two factors previously mentioned.

The method of loading the mills has a great deal to do with this final ferritic grain size, for, with certain reductions on the last stand in a particular temperature range, excessive grain growth will occur. Thus, in hot rolling, a similar critical grain-growth range exists as in cold rolling. This critical growth range is depicted in a three-dimensional diagram in Fig. 2. The peaks in this diagram represent exaggerated grain growth.

While the diagram will be found to have been derived from data on single-stand rollings (4),[3] still, the basic principle has been found to apply also on the continuous-strip mills.

In 1913 and 1916, P. Oberhoffer (1, 2) carried out experiments dealing with the effects of forging at different temperatures on the ferritic grain size. Hanemann and Lucke (3) constructed a quite complete three-dimensional diagram for the effect of forging upon the grain size. However, since it was felt that the grain size, following recrystallization, depended upon the strains in the

---

[1] Assistant General Superintendent, Sheet and Tin Mills, Chicago District, Carnegie-Illinois Steel Corporation. Mr. Angle was graduated from Lehigh University in 1932 with the degree of B.S. in metallurgical engineering. After graduation, he was employed by the American Sheet & Tin Plate Company in the metallurgical department of the Gary Sheet Mill, Gary, Indiana. In 1935, he was appointed plant metallurgist, in which capacity he served until the consolidation of the American Sheet & Tin Plate Company with Carnegie-Illinois Steel Corporation.

[2] Strip Metallurgist, Metallurgical Department, Pittsburgh District, Carnegie-Illinois Steel Corporation. Mr. McGarrity, was graduated from Lehigh University in 1931 with the degree of B.S. in chemical engineering. In 1931 he joined the research staff of The Youngstown Sheet & Tube Company as metallographist. During 1933–1934, on a year's leave of absence, he was an exchange scholar from the United States to Germany, at the Bergakademie, Freiberg in Saxony, Germany. Returning to the Youngstown Sheet & Tube Company, he became assistant metallurgist of hot strip. Early in 1936, Mr. McGarrity joined the Carnegie-Illinois Steel Corporation at the McDonald Works as metallurgist of the 43" hot-strip mill; late last year, being transferred to the Pittsburgh Office in his present position.

Contributed by the Iron and Steel Division and presented at the Semi-Annual Meeting of The American Society of Mechanical Engineers, Detroit, Mich., May 17–21, 1937.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until September 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

[3] Numbers in parentheses refer to the Bibliography at the end of the paper.

material, and since rolling left strains which were different from forging, Tafel, Hanemann, and Schneider (4) undertook to study the effect of hot rolling on recrystallization. They found the diagram for hot rolling to be different from that obtained for forging. Also, it was concluded that the initial grain size had nothing whatsoever to do with the final grain size. Instead, it was really the reduction in area and temperature of the last pass which determined the final grain size, with the change in structure due to previous passes exerting no influence.

The reduction in the last pass on a hot-strip mill is usually not within the particular critical range herein described as it is more often around 9 to 15 per cent, depending on the condition of the rolls before the last stand, the width of strip, and the gage being rolled. Nevertheless, the surface layers of the strip are often projected into the critical grain-growth range when rolled under A_3 by the amount of cold work on the surface, the spontaneous self-annealing giving rise to the recrystallized coarse surface grain appearing in Fig. 1. Segregation in the center of the strip has prevented grain growth in that region.

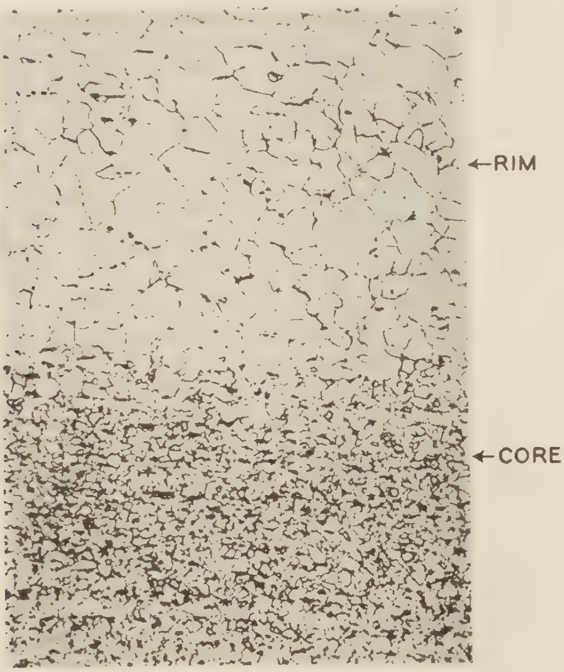


Fig. 1 Typical Structure of Hot Strip Finished Within Critical Rolling Range ×100

In the absence of marked center segregation, and when the reduction and temperature have been such as to be outside of the critical range applying to continuous mills, similar to but not the same as Fig. 2, an equiaxed, medium-sized grain can be obtained (Fig. 4) at temperatures below the A_3 point. It is well known that strip which has been finished above its A_3 point will exhibit small normalized grains, their ultimate size depending upon the temperature and rate of cooling.

In actual practice the microstructure of hot strip varies as follows: If finished above A_3, as the steel enters the last stand, the strip will consist of small normalized grains (Fig. 3). As the finishing temperature drops slightly below this point for a low-carbon steel, the percentage of reduction being suitable, a radical change in structure suddenly becomes apparent. Instead of the small normalized grains, coarse surface grains, or large grains throughout, are found; pebbly Olsen buttons are observed, and the Rockwell value drops to below 48 B. However, it is quite fortunate that beneath this critical range, with a suitable percentage of reduction, is a range where the greatest proportion of strip will consist of quite desirable, soft, medium-sized grains, having hardness values of approximately 50 to 56 B. For deep-drawing hot-rolled sheets, where finishing temperatures above A_3 are not possible, material finished in such a manner has performed quite successfully.

It might be pointed out, however, that strip without such an ideal hot-rolled structure, and with higher hardness values than are considered desirable, often has performed drawing operations which were not considered by many to be possible. Where

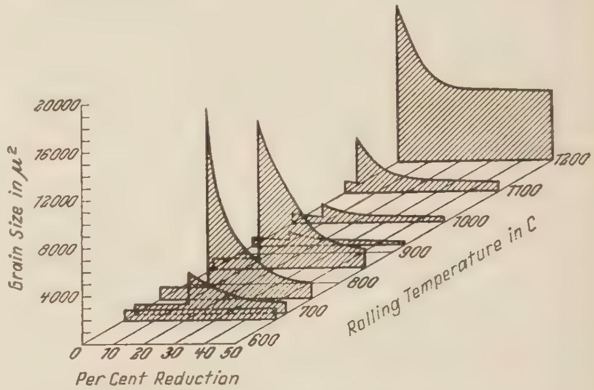


Fig. 2 Recrystallization of Low-Carbon Steel After Hot Rolling (4)

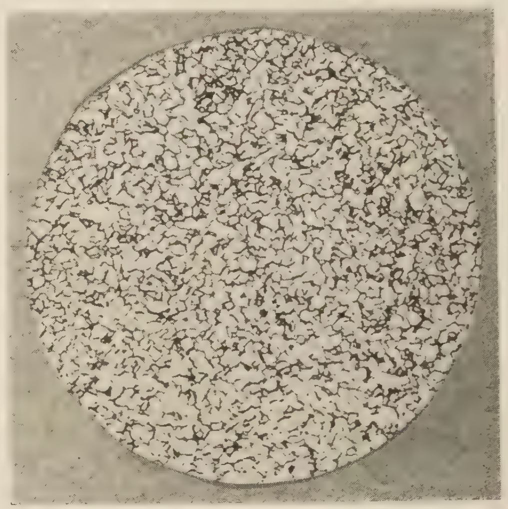


Fig. 3 Typical Structure of Strip Finished Above 1600 F ×100

extra-deep-drawing qualities are required, such strip should be normalized.

When heavier gage material, around 0.135 gage, is finished above the upper critical range, the hardness is appreciably increased over that which would normally be obtained if the strip were finished slightly under this range. Hardening in this case is due both to the refinement of the grains upon passing A_3 and the rapid cooling through the critical range, which affects the form of pearlite. For deep-drawing work, regardless of the slightly higher Rockwell values, this homogeneous material is considered best.

Certain operating limitations make this rather high finishing

temperature difficult to maintain. Chief among them is the formation of a so-called "heat pattern" on the surface of the strip, which, if neglected, will break into rolled-in scale. Appearing at first as a mottled design along one portion of the strip, unless the temperature is dropped, or several rolls in the finishing train are changed, the mottled design spreads across the width of the strip until the whole surface is covered, and later becomes much deeper in effect, resulting in rolled-in scale, with surface pitting. When finishing at higher temperatures, however, besides obtaining more uniform physical properties in the strip, less power is consumed, the strip is easier for the speed operators to handle, and the crown on the rolled material is decreased. Needless to say, too, production can be kept at a high rate.

In the application of the three-dimensional diagram of Fig. 2, it should also be realized that other factors limit the percentage reduction on the finishing stand. With too great a reduction, the proper shape of the strip cannot be attained, the possibility of stretching between the last two stands is increased, and excessive gage variations may result.

Hot and Cold Coiling

Considerable discussion is heard regarding the effect of coiling strip hot and coiling strip cold, especially on wider strip mills. In the authors' experience, the effects of hot coiling are not great, as far as the microstructure is concerned, unless the strip is over approximately 0.083 gage, the coiler quite close to the finishing stands, or the coil extremely heavy. A slight coarsening effect may take place, but the structure is fairly well fixed as it comes out of the last finishing stand, and the cooling is so relatively rapid, both as the strip progresses down the run-out table and while in the coil, that little annealing is possible. The annealing which does take place, however, affects the yield point more than anything else, and tends to coagulate the carbides. Material

Fig. 4 Typical Structure of Strip Finished Below A_3, Outside of Critical Hot-Rolling Range ×100

coiled cold will be found in general to have a proportionally higher elastic ratio than material coiled hot. There is some danger of grain growth in hot-coiled material which possesses a duplex structure (i.e., fine and large grains), although for the light gages, unless coiled very hot, this growth is not considered to be serious.

The use of water on the run-out table to cool the hot strip is excellent practice for strip which will be subsequently cold-rolled and annealed. Quenching tends to assist in the recrystallization of cold-rolled strip, and after annealing, apparently makes for smaller grains with well-dispersed carbides. Quenching by water will tend to show quite angular grains in the microstructure of material finished above A_3. On material finished under A_3, it is considered as a safeguard against possible grain growth in the coil.

Skin Passing, Its Effect on Hardness

For flattening hot-rolled strip, a two-high skin mill is often used in conjunction with roller levelers. With such a mill, only small amounts of reductions are effected per pass. Reductions of more than 0.003 in. are seldom accomplished, the precise reduction varying with the width of strip, the composition, and the grain structure (i.e., ease of deformation) of the metal.

If the material has a fine ferritic grain, it will have a tendency to harden much more than coarse-grain strip with the same amount of reduction. With a reduction of 0.003 in. for a low-carbon, medium-width strip, say 30 in. wide, and 0.130 gage, the hardness increase will be approximately three points, Rockwell B scale. For a lighter gage (e.g., 0.049 in.), and wider strip, the increase in hardness often amounts to six or eight points, providing the structure is fine.

The Heat-Treatment of Hot Strip

As mentioned previously, when extra-deep-drawing qualities are desired from light-gage material which was not finished on the mill in such a way as to obtain a normalized structure, a normalizing treatment must be applied. Likewise, to soften and improve the properties of strip finished above A_3, a normalizing treatment is frequently given the material. When strip, finished off the mill in this latter manner, is normalized, the originally small, even, normalized grains become uniformly larger, the general increase in grain size depending upon the temperature and speed of normalizing and also on the rate of cooling. At the same time and proportionally to these factors, the material becomes softer, the yield point is lowered, and the elongation increases. The tensile strength does not change appreciably, regardless of the speed of normalizing.

When strip or sheets which have been finished on the mill in such a way as to have a duplex structure similar to that of Fig. 1 are normalized, the large surface grains are reduced in size, and the fine interior grains increase in size, so that across the sheet a practically homogeneous ferritic grain size is obtained.

Normalizing, however, unless a suitable furnace atmosphere is maintained, produces a heavy loose scale which is particularly detrimental to die life. Also, where the formed or drawn part is later to be painted or lacquered, a normalized sheet without the scale removed cannot be used for exposed parts. Hence, for these purposes, pickling the normalized sheet or strip is imperative.

For the softening of hard strip where no pickling is allowed, a box anneal is highly desirable. This treatment is carried out at a relatively low temperature, as serious grain growth can be encountered even for short soaking periods, at high temperatures.

Hot Strip to Cold Strip

It has been known for some time that, given sufficient cold reduction, strip can be recrystallized into small or medium-sized equiaxed grains by a box anneal alone. With the older-type two-high cold-reduction mills, the amount of cold reduction was so slight that a normalizing treatment had to be inserted in the process to avoid serious grain growth upon annealing (5). With strip made from four-high tandem cold-reduction mills or other mills which effect heavy reductions in a number of passes normalizing has been done away with almost completely.

The effect of cold reduction is to break up and destroy the hot-rolled grain structure by elongating the grains, Fig. 5. Naturally, a considerable hardening results from the cold-working, and the low-carbon cold-reduced strip usually leaves the mill with a

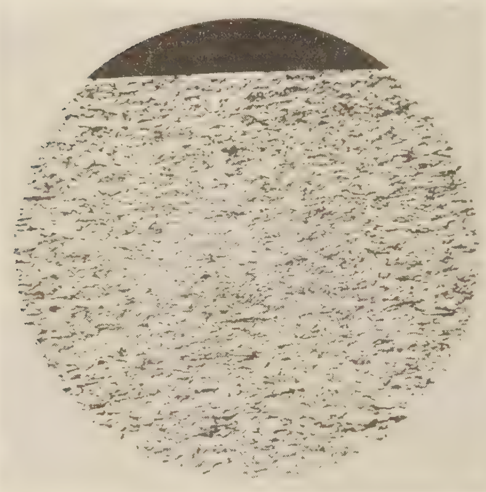


Fig. 5 Typical Cold-Rolled Strip Structure ×100

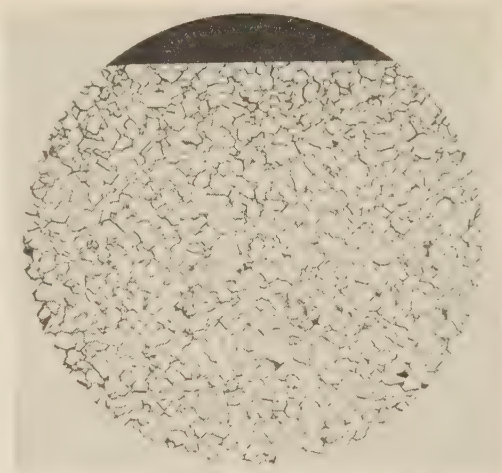


Fig. 6 Typical Cold-Rolled and Box-Annealed Strip for Automobile Sheets ×100

hardness of about 95 Rockwell B. During the cold-working, the rate of hardening is quite rapid at first, then the rate decreases gradually approaching a maximum value. A difference of 10 points Rockwell in the hot-rolled strip may resolve to a difference of as small as one point after sufficient cold reducing.

When reductions totaling some 50 to 65 per cent are effected in these wide four-high mills, with the strip becoming continually harder, pressures of from one to two million pounds per screw are necessary to secure the reductions. Obviously, such pressures place a tremendous strain on the bearings, and these can be one of the most expensive items of cost on either a tandem or reversing mill.

Given this amount of cold reduction, cold-rolled strip can be recrystallized most conveniently by box annealing at temperatures of 1200 to 1380 F. Even at much lower temperatures, recrystallization will take place, but the time required for its completion is excessively long. Box-annealing practices may be divided arbitrarily into two general classifications, either one or the other being used in the cold-strip process, with preference depending upon individual plant supervision. They are: (*a*) box annealing above the A_1 point (1330 to 1380 F approximately), and (*b*) box annealing just below the A_1 point (1200 to 1330 F). Each has its advantages, the former chiefly in the rapidity of the anneal; the latter in the retention of smaller grains and the absence of sticking.

In general, for various deep-drawing applications, the Rockwell hardness of the annealed strip will vary between 40 and 50 B, depending upon the composition of the steel, the grain structure of the hot strip, and the annealing cycle. The A.S.T.M. ferrite grain size will fall between No. 6 and No. 8, and will consist on the whole of quite uniform and equiaxed grains, Fig. 6. The tensile strength will be about 45,000 lb per sq in. yield point about 27,000 lb per sq in., and elongation in the standard 2 in. × 0.500 in. sheet-test specimen of from 35 to 40 per cent with strip 0.0375 in. thick. The character of the yield point is quite interesting. In general, a uniform stress-strain rate will persist to perhaps 28,000 lb, whereupon plastic deformation will begin. Usually, the yield point will then drop as much as a thousand pounds, while considerable elongation occurs. Then, the steel will harden again, and the strength will increase to the breaking point. This elongation at the yield point has been shown to be closely related to stretcher straining (6, 7, 8, 9, 10, 11). It appears that under tension, steel of this sort does not yield uniformly, but that blocks of crystals give way as if they were weaker than their companions. After elongating slightly, not over 10 per cent, there has been sufficient work hardening to increase their strength to that of the rest of the section. The slippage of these blocks of grains shows up on the surface of the steel in lines of depression termed stretcher strains. After more elongation has taken place, they will pull out the remainder of the metal and therefore disappear. In shallow stampings, where the steel is not elongated over 10 per cent these lines will be evident and usually objectionable.

Curiously enough, the slight strain or set imparted to the steel by as little as 1 per cent elongation in temper rolling is usually sufficient to eliminate this tendency, at least temporarily. It is thought that the slight cold working fills the grains of the sheet with slip planes, enabling it to stretch evenly. This is demonstrated quite clearly by the stress-strain diagram of a tensile test. Where before temper rolling there was a pronounced halt at the yield point, there is none after sufficient temper rolling, the curve being smooth to the breaking point.

The other physical tests show little change after 1 per cent temper rolling. Rockwell-hardness values may increase 1 or 2 points, the Olsen cup is generally the same, and the per cent elongation and tensile strength undergo very little change, when tested within a day of temper rolling.

However, what both producers and consumers of cold-rolled strip steel have learned through experience is that an aging process begins immediately after the work hardening produced by temper rolling. The cold working evidently places the steel in an unstable condition, and there is a continual tendency to revert to the original or stable state (12). Unfortunately, the tendency to stretcher strain returns, while the hardness, yield point, and tensile strength increase, with the ductility suffering at the same time. Depending upon the atmospheric temperature at which the steel is held, complete aging may occur in several weeks or in several months. It can be tremendously accelerated by boiling in water or heating in oil at 400 F where it will age in a few minutes.

Where rather large stocks of cold-rolled sheets must necessarily be carried, with some delay between their arrival and use, both the producer and the manufacturer have greatly benefited by the installation of roller levelers at the point where the sheets are to be used, since the effect of aging, as manifested by a return to stretcher straining, is greatly reduced or completely eliminated by this processing.

ACKNOWLEDGMENT

The authors acknowledge the kind cooperation of various members of the Carnegie-Illinois Steel Corporation for their assistance in the preparation and assembly of data for this paper.

BIBLIOGRAPHY

1 "Ueber den Einfluss des Schmiedens auf die Eigenschaften eines weichen Flusseisens," by P. Oberhoffer, *Stahl und Eisen*, vol. 33, September, 1913, pp. 1507 and 1564.

2 "Ueber die Ergebnisse von Schmiedeversuchen mit Flusseisen und Stahl," by P. Oberhoffer, L. Lauber, and H. Hammel, *Stahl und Eisen*, vol. 36, March, 1916, pp. 234–238.

3 "Rekristallisation nach Warmverformung," by H. Hanemann and F. Lucke, *Stahl und Eisen*, vol. 45, July, 1925, pp. 1117–1122.

4 "Die Rekristallisation beim Warmwalzen," by W. Tafel, H. Hanemann, and A. Schneider. *Stahl und Eisen*, vol. 49, January, 1929, pp. 7–12.

5 "A Study of the Influence of Varying Degrees of Cold Rolling and Annealing Temperatures on the Properties of Mild Steel Sheets," by C. A. Edwards, D. L. Phillips, and W. H. E. Gullick, *Journal of the British Iron & Steel Institute*, vol. 83, no. 1, 1936, p. 95P.

6 "Sheet Steel and Strip Steel for Automobile Bodies," by J. Winlock and G. L. Kelley, Transactions of the American Society for Steel Treating, vol. 18, 1930, pp. 254–261.

7 "Autographic Stress-Strain Curves of Deep Drawing Sheets," by R. L. Kenyon and R. S. Burns, Transactions of the American Society for Steel Treating, vol. 21, 1933, p. 594.

8 "Some Effects of the Amount and Rate of Deformation on a Low-Carbon Strip Steel," by J. Winlock and A. E. Lavergne, Transactions of the American Society for Steel Treating, vol. 21, 1933, p. 115.

9 "Aging of Mild Steel Sheets," by R. O. Griffis, R. L. Kenyon, and R. S. Burns, Yearbook, The American Iron & Steel Institute, 1933, pp. 142–161.

10 "The Cold Rolling of Mild Steel Sheets and Strip," by A. Hayes and R. S. Burns, Transaction of the American Society for Metals, vol. 25, March, 1937, pp. 129–162.

11 "Some Factors Affecting the Plastic Deformation of Sheet and Strip Steel and Their Relation to the Deep Drawing Properties," by J. Winlock and R. W. E. Leiter, Transactions of the American Society for Metals, vol. 25, March, 1937, pp. 163–205.

12 "The Aging of Steel," by E. S. Davenport and E. C. Bain, Transactions of the American Society for Metals, vol. 23, December, 1935, pp. 1047–1106.

Cooperative Creep Tests on 0.35 C Steel K20 at 850 F and 7500 Lb per Sq In.

By C. L. CLARK,[1] ANN ARBOR, MICH.

TENTATIVE A.S.T.M. Standards have been prepared by the Joint Research Committee on Effect of Temperature on the Properties of Metals covering both short-time tensile and creep tests at elevated temperatures. Last year a report[2] was submitted by Subcommittee D of Committee 3 setting forth the results obtained by several laboratories from short-time tensile tests at 850 F on a 0.35 per cent carbon steel designated as K20.

The present report, which should be considered as one of progress rather than as a final one, pertains to results obtained from creep tests on this same steel, at 850 F under a stress of 7500 lb per sq in. The procedure recommended in the tentative standard was followed and the steel, which was from the same heat as that used for the short-time tensile tests, is believed to be as uniform as can be obtained on the basis of present knowledge.

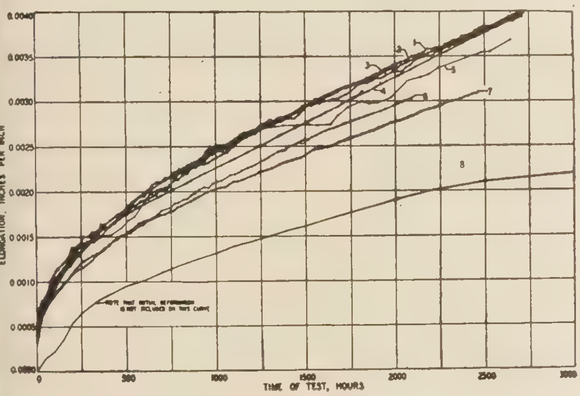


FIG. 1 TIME-ELONGATION CURVES OBTAINED BY EIGHT COOPERATING LABORATORIES, 850 F, 7500 LB PER SQ IN. STRESS

An open invitation was extended to all laboratories to cooperate, and nine requested material for tests. Eight of these nine laboratories have submitted their findings and the ninth has indicated that results will not be forthcoming. The eight cooperating laboratories, arranged alphabetically, are Babcock and Wilcox, Battelle, Bethlehem, Crane, General Electric, Midvale, University of Michigan, and U. S. Steel Research.

The actual time-elongation curves submitted are set forth in Fig. 1. The laboratories are designated with numbers but these do not correspond to the alphabetical listing. It is to be noted that in seven cases the initial deformation obtained upon the application of the load is included while in one case it is not.

TABLE 1 PLASTIC DEFORMATIONS OBTAINED BY COOPERATING LABORATORIES AT DESIGNATED TIME PERIODS

(Steel K20 [0.35 C] at 850 F, 7500 lb per sq in. stress)

Time period, hr	Deformation, per cent, as obtained by indicated laboratories 1	2	3	4	5	6	7	8
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	0.092	0.096	0.100	0.116	0.108	0.085	0.076	0.065
500	0.136	0.144	0.125	0.136	0.132	0.118	0.114	0.095
750	0.166	0.179	0.165	0.161	0.175	0.147	0.139	0.114
1000	0.202	0.209	0.180	0.187	0.213	0.175	0.164	0.131
1500	0.253	0.257	0.240	0.237	0.241	0.221	0.201	0.161
2000	0.298	0.300	0.275	0.287	0.276	0.260	0.238	0.190
2500	0.336	0.340	0.320	0.338	0.323	...	0.274	0.210
3000	0.382	...	0.359	0.388	...	...	...	0.219

TABLE 2 CREEP RATES OBTAINED BY COOPERATING LABORATORIES AT DESIGNATED TIME PERIODS

Time period, hr	Creep rate, per cent per 1000 hr, as obtained by indicated laboratories 1	2	3	4	5	6	7	8
250	0.232	0.244	0.150	0.206	0.158	0.158	0.162	0.156
500	0.160	0.160	0.135	0.131	0.146	0.140	0.121	0.100
750	0.125	0.121	0.120	0.100	0.120	0.112	0.099	0.077
1000	0.125	0.114	0.088	0.100	0.120	0.103	0.077	0.067
1500	0.097	0.094	0.066	0.100	0.090	0.083	0.075	0.057
2000	0.090	0.086	0.066	0.100	0.090	0.075	0.073	0.056
2500	0.082	0.078	0.066	0.100	0.090	...	0.072	0.027
3000	0.082	...	0.066	0.100	...	...	...	0.019

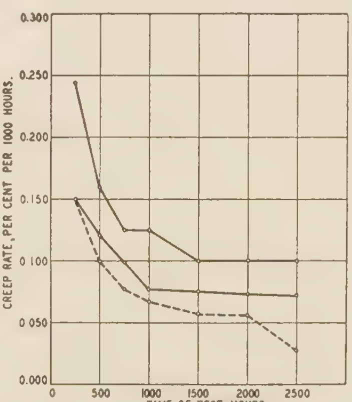


FIG. 2 RANGE OF CREEP-RATE VALUES OBTAINED BY COOPERATING LABORATORIES

From curves of this type both the total plastic deformation and the creep rates at indicated times can be obtained. Table 1 shows the plastic deformations obtained by the various laboratories at the indicated time periods. In order to make the results from all eight laboratories comparable the initial deformation, occurring upon the application of the load, was not considered. The deformations are expressed in per cent and it will be noted that at 250 hr the maximum range is from 0.065 to 0.116 per cent while at 2000 hr, the range is from 0.190 to 0.300 per cent.

[1] Research Engineer, Department of Engineering Research, University of Michigan. Mr. Clark received the degrees of B.S. in chemical engineering in 1925, M.S. in 1926, and Ph.D. in 1928, from the University of Michigan. He has specialized in metallurgy and has served in the department of engineering research at the University of Michigan since 1928.

[2] "Short-Time Tensile Tests at 850 F of the 0.35 Per Cent Carbon Steel Material K20," Trans. A.S.M.E., vol. 58, 1936, paper RR-58-4, pp. 97–101.

Contributed by the A.S.M.E.-A.S.T.M. Joint Research Committee on the Effect of Temperature on the Properties of Metals, Subcommittee E of Committee 3, and presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, held in New York, N. Y., November 30 to December 4, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until September 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Table 2 shows the creep rates obtained by the cooperating laboratories at the designated time periods. The creep rates are expressed in per cent per 1000 hr and are defined as the tangents to the curves at the indicated time periods. The range in these values can best be seen from Fig. 2 which shows the same results graphically. Since the results obtained from laboratory 8 were consistently lower, their values are indicated by a separate line rather than by inclusion in the general range. It will be noted that the range in the creep rates tends to decrease with increasing time and at 2500 hr the total range, for seven of the eight laboratories, is from 0.066 to 0.100 per cent per 1000 hr.

In evaluating these results it cannot of course be assumed that all of the material possessed exactly the same creep resistance. Certain of the available information indicates that not only may variations in the creep resistance exist in different heats of the same analysis but also in different portions of the same heat.

Long-Time Creep Tests of 18 Cr 8 Ni Steel K19 and 0.35 C Steel K20

By HOWARD C. CROSS[1] and J. G. LOWTHER,[2] BATTELLE MEMORIAL INSTITUTE, COLUMBUS, OHIO

This paper, submitted under the sponsorship of the Joint A.S.T.M.-A.S.M.E. Research Committee on Effect of Temperature on the Properties of Metals, is a report on long-time creep tests now in progress on water-quenched 18 per cent Cr, 9.5 per cent Ni, 0.067 per cent C steel K19 at 1200 F and on an annealed 0.35 per cent C steel K20 at 850 F.

One test on the K19 steel loaded to 8345 lb per sq in. at 1200 F was discontinued at 11,467 hours and a second test has now progressed to 15,185 hours.

Of the K20-steel tests at 850 F, one test at 8000 lb per sq in. was discontinued at 10,955 hours, and a second test at 7500 lb per sq in. has now progressed to 12,214 hours.

Introduction

THE STEELS under test have been fully described in previous reports to the Joint Committee and in reports presented to the A.S.M.E.[3,4] and the data herein contained set forth recent results of the continuing tests previously reported to the sponsor societies.[5,6]

[1] Member of research staff, Battelle Memorial Institute. Upon graduation from high school Mr. Cross entered the Metallurgical Division of the Bureau of Standards. While so employed he attended George Washington University, being graduated in 1927 with the degree of B.S. in chemical engineering. In December, 1929, he joined the research staff of the Battelle Memorial Institute. In his work at both the Bureau of Standards and the Institute, Mr. Cross has concentrated on the investigation of the properties of metals at elevated temperatures.

[2] Member of research staff, Battelle Memorial Institute. Mr. Lowther was graduated from the University of Texas in 1928 with the degree of B.S. in mechanical engineering. From 1928 to 1932 he was associated as research assistant in mechanical engineering at the Engineering Experiment Station of the University of Illinois, working on flow of air through orifices. In 1931 he received the degree of M.S. from the University. At the close of that period he was transferred to the applied-mechanics department where his work dealt with fatigue and measurement of stresses in rails. Since September, 1935, he has been connected with the Battelle Memorial Institute on the design and testing of tin-base bearings and on creep of steel at elevated temperatures.

[3] "High-Temperature Tensile, Creep, and Fatigue of Cast and Wrought High- and Low-Carbon 18 Cr 8 Ni Steel From Split Heats," by H. C. Cross, Trans. A.S.M.E., vol. 56, 1934, paper RP-56-6, p. 533.

[4] "Short-Time Tensile Tests at 850 F of the 0.35 Per Cent Carbon Steel, Material K20," Trans. A.S.M.E., vol. 58, 1936, paper RP-58-4, p. 97.

[5] "Long-Time Creep Tests of 18 Cr 8 Ni Steel and 0.35 Per Cent Carbon Steel," by H. C. Cross and F. B. Dahle, Trans. A.S.M.E., vol. 58, 1936, paper RP-58-3, p. 91.

[6] "Long-Time Creep Tests of 18 Cr 8 Ni Steel and 0.35 Per Cent Carbon Steel," by H. C. Cross and F. B. Dahle, Proc. A.S.T.M., vol. 36, 1936, p. 143.

Contributed by the A.S.M.E.-A.S.T.M. Joint Research Committee on the Effect of Temperature on the Properties of Steam and presented at the Annual Meeting of The American Society of Mechanical Engineers, held in New York, N. Y., November 30 to December 4, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until September 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

Creep Tests

18 Cr 8 Ni Steel K19. The time-deformation curves for the 18 Cr 8 Ni steel at 1200 F and 8345 lb per sq in. are shown in Figs. 1 and 2. Table 1 gives a summary of their creep-test data.

At 10,127 hr, the load on specimen B12-4 was removed but the temperature was maintained at 1200 F. The rate of deformation at this time was about 0.000475 per cent per hour and the total deformation was 2.962 per cent.

At the start of the test on specimen B12-4, the deformation resulting from the application of the load was 0.067 per cent. The immediate contraction upon release of the load was about 0.048 per cent, and during the 645 hr at temperature under zero load further contraction to a total of 0.071 per cent took place. At 10,772 hr the load of 8345 lb per sq in. was reapplied and the resultant deformation was 0.045 per cent. After maintaining the load for 695 hr to a total of 11,467 hr, during which time the rate of deformation was about 0.00053 per cent per hr, the load was removed and the immediate contraction was 0.047 per cent.

It may be seen that the contraction resulting from release of the load was of about the same magnitude as the deformation resulting from application of the load. This indicates that the deformation subsequent to that measured upon application of the load is permanent and not recoverable for an 18 Cr 8 Ni steel tested at 1200 F and 8345 lb per sq in.

The test on specimen B12-1 is still in progress at 15,185 hr with a rate of deformation of about 0.00037 per cent per hr and a total deformation of 3.871 per cent. Since the last report at 11,257 hr, the rate has gradually increased from 0.00029 to 0.00037 per cent per hr.

The total deformation of specimen B12-1, nearly 3.9 per cent, is well above that which some designers consider inadmissible for heat-resisting austenitic alloys, even when change of dimensions is not harmful, on the score that brittle failure is impending. The further course of the curve, and whether the specimen continues to stretch or whether it will fail suddenly and in brittle fashion, will be of especial interest.

0.35 C Steel K20. The time-deformation curves for the 0.35 per cent carbon steel at 850 F are shown in Figs. 3 and 4, and Table 2 gives a summary of their creep-test data.

At 9617 hr, the load on specimen 10A-4 (8000 lb per sq in.) was removed but the temperature was maintained at 850 F. The rate of deformation at this time was about 0.000095 per cent per hr and the total deformation was 1.173 per cent.

At the start of the test on specimen 10A-4, the deformation resulting from the application of the load was 0.04 per cent. The immediate contraction upon release of the load was about 0.039 per cent and during the 643 hr at temperature under zero load, further contraction to a total of 0.064 per cent took place. At 10,260 hr the load of 8000 lb per sq in. was reapplied and the resultant deformation was about 0.045 per cent. After maintaining the load for 695 hr to a total of 10,955 hr during which time the rate of deformation was about 0.00011 per cent per hr, the load was removed and the immediate contraction was about 0.043 per cent.

Since this specimen 10A-4 after one per cent total deformation showed a maximum contraction of only about 0.02 per cent more on release of the load than of deformation on application of the

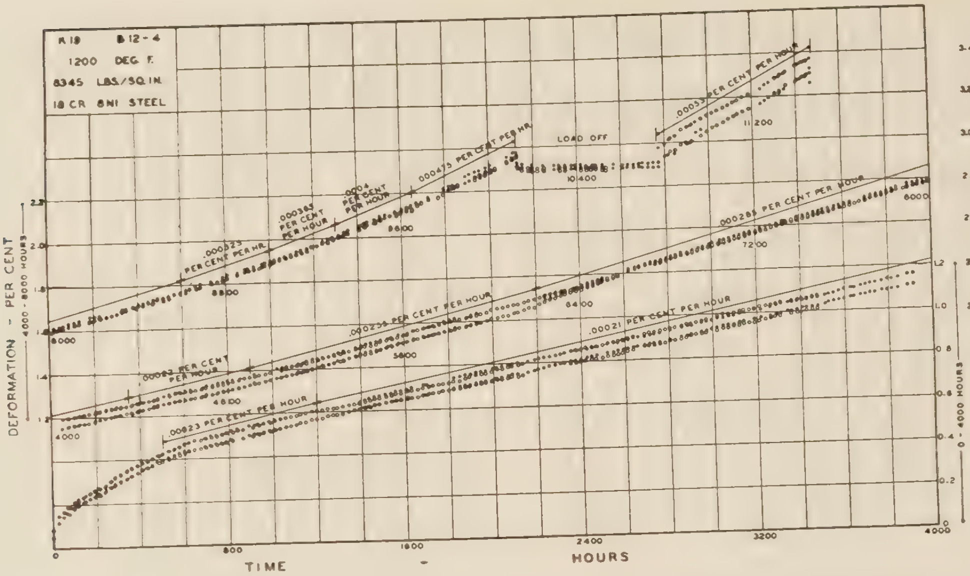


Fig. 1 Time-Deformation Curves at 1200 F for 18 Cr 8 Ni Steel K19, Specimen B12-4

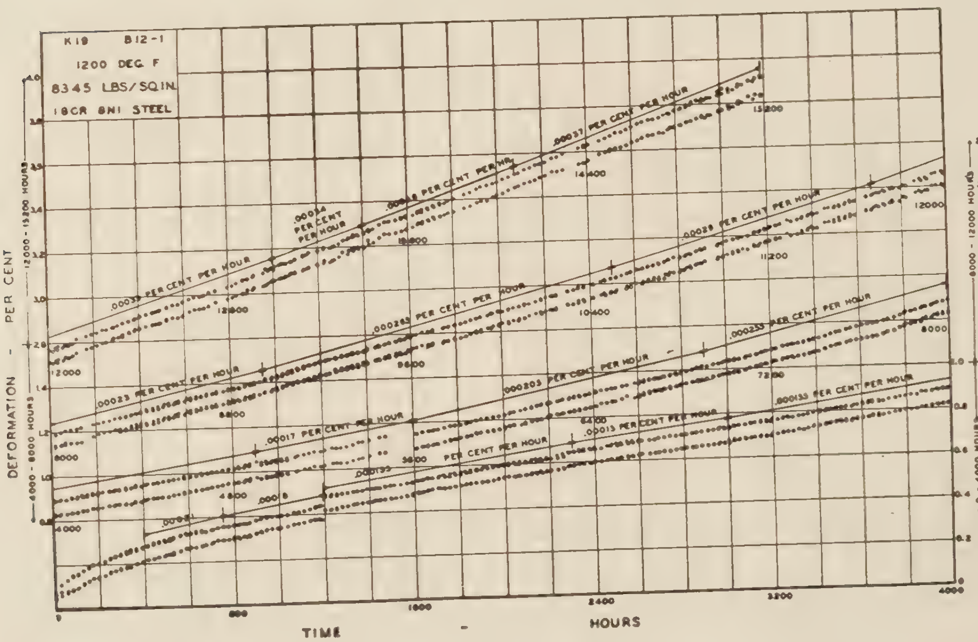


Fig. 2 Time-Deformation Curves at 1200 F for 18 Cr 8 Ni Steel K19, Specimen B12-1

load, practically all of the deformation subsequent to that measured upon application of the load is indicated to be permanent and not recoverable upon unloading.

The test on specimen 25B-5 is still in progress at 12,214 hr with a rate of deformation of about 0.000065 per cent per hr and a total deformation of about 1.045 per cent. The rate has remained practically constant between 0.00006 and 0.000065 per cent per hr since the last report at 8279 hr.

Discussion of the Results of the Creep Tests

For greater ease of comparison the time-deformation curves for the four specimens which were tested are shown as single curves in Fig. 5.

The tests still running have progressed an additional 3825 hr since the last report and continue to indicate that the actual deformations are considerably greater than the values obtained by extrapolation from 2000 hr at the average rate observed between 1000 and 2000 hr for the 18 Cr 8 Ni steel at 1200 F and less than the extrapolated values for the 0.35 per cent carbon steel at 850 F.

For specimen B12-1, the extrapolated value at 15,000 hr would be about 2.43 per cent, whereas the increasing rate since about 3000 hr has caused an actual deformation at 15,000 hr of about 3.81 per cent or about 57 per cent higher than the value estimated by extrapolation.

For specimen B12-4 which has been discontinued at the shorter time of 10,127 hr, the extrapolated value at 10,000 hr would be about 2.42 per cent as compared with the observed actual value of 2.91 per cent, which is about 20 per cent higher. This dif-

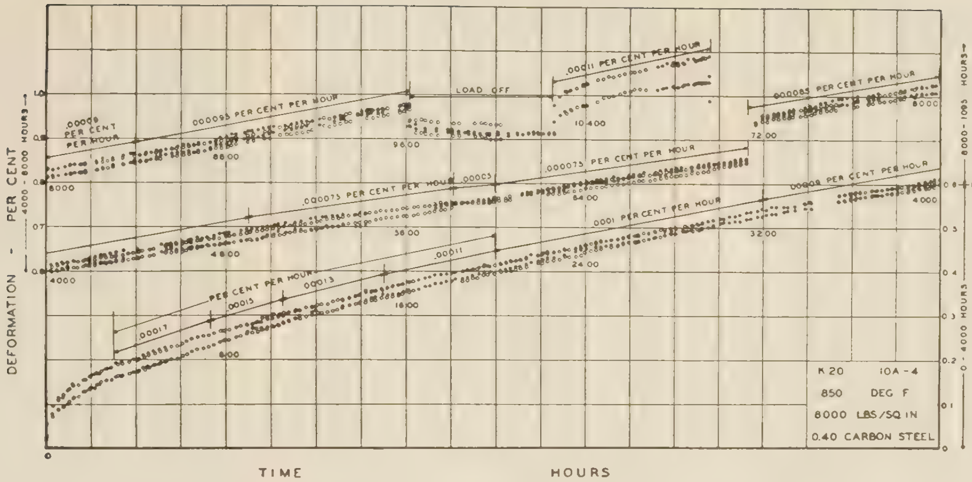


FIG. 3 TIME-DEFORMATION CURVES AT 850 F FOR 0.35 C STEEL K20, SPECIMEN 10A-4

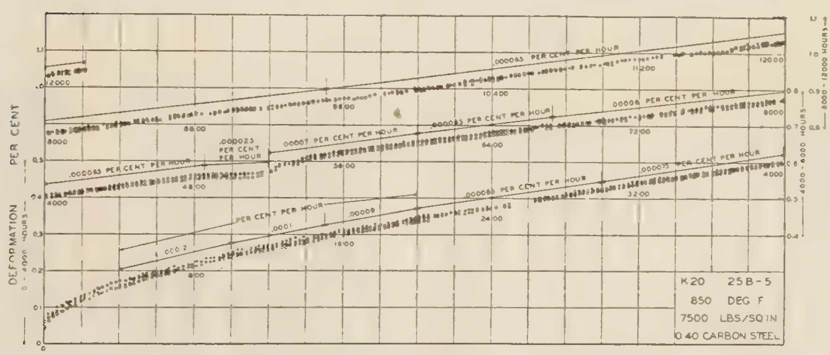


FIG. 4 TIME-DEFORMATION CURVES AT 850 F FOR 0.35 C STEEL K20, SPECIMEN 25B-5

TABLE 1 CREEP-TEST DATA FOR 18 CR 8 NI STEEL K19 TEST TEMPERATURE 1200 F; LOAD 8345 LB PER SQ IN.

Specimen number	B12-4		B12-1	
Initial deformation, per cent	0.06		0.06	
Duration of test, hr	11,467		15,185	
	Rate of deformation per cent per hr	Total def. per cent	Rate of deformation per cent per hr	Total def. per cent
500	0.00043	0.41	0.00021	0.27
1000	0.00023	0.54	0.00018	0.36
1600	0.00021	0.67	0.000155	0.50
2000	0.00021	0.75	0.000155	0.57
3000	0.00021	0.96	0.00013	0.70
4000	0.00021	1.16	0.000155	0.86
5000	0.000255	1.45	0.00017	1.01
6000	0.000255	1.63	0.000205	1.19
7000	0.000285	1.92	0.00021	1.40
8000	0.00028	2.19	0.000255	1.66
9000	0.000365	2.49	0.000265	1.89
10000	0.000475	2.90[a]	0.00026	2.11
11000	......	...	0.00029	2.44
12000	......	...	0.000325	2.74
13000	......	...	0.000335	3.081
14000	......	...	0.000355	3.442
15000	......	...	0.00037	3.807[b]

[a] At 10,127 hr and 2.962 per cent deformation: immediate contraction upon release of load, 0.048 per cent; greatest contraction during 645 hr at temperature under zero load, 0.071 per cent; immediate deformation upon reapplication of load at 10,772 hr, 0.045 per cent; load on for 695 hr; load off at 11,467 hr; immediate contraction upon release of load, 0.047 per cent; test discontinued.

[b] Test continuing, rate 0.00037 per cent per hr and deformation 3.871 per cent at 15,185 hr.

TABLE 2 CREEP-TEST DATA FOR 0.35 CARBON STEEL K20 TEST TEMPERATURE 850 F

Specimen number	10A-4		25B-5	
Load-lb per sq in.	8000		7500	
Initial deformation per cent	0.04		0.05	
Duration of test, hr	10955		12214	
	Rate of deformation per cent per hr	Total deformation per cent	Rate of deformation per cent per hr	Total deformation per cent
500	0.00017	0.21	0.00012	0.175
1000	0.00015	0.28	0.00012	0.24
1400	0.00013	0.34	0.00010	0.28
2000	0.00011	0.40	0.00009	0.34
3000	0.00010	0.51	0.00009	0.425
4000	0.00009	0.605	0.000075	0.50
5000	0.000075	0.688	0.000025	0.56
6000	0.000075	0.763	0.00007	0.60
7000	0.000075	0.844	0.00006	0.712
8000	0.000085	0.919	0.00006	0.773
9000	0.000095	1.015[a]	0.00006	0.839
10000	......	...	0.000065	0.899
11000	......	...	0.000065	0.969
12000	......	...	0.000065	1.037[b]
13000	......	...		

[a] At 9617 hr and 1.173 per cent total deformation: immediate contraction upon release of load, 0.039 per cent; greatest contraction during 643 hr at temperature under zero load, 0.064 per cent; immediate deformation upon reapplication of load at 10,260 hr, 0.045 per cent; load on for 695 hr; load off at 10,955 hr; immediate contraction upon release of load, 0.043 per cent; test discontinued.

[b] Test continuing, rate 0.000065 per cent and deformation 1.045 per cent at 12,214 hr.

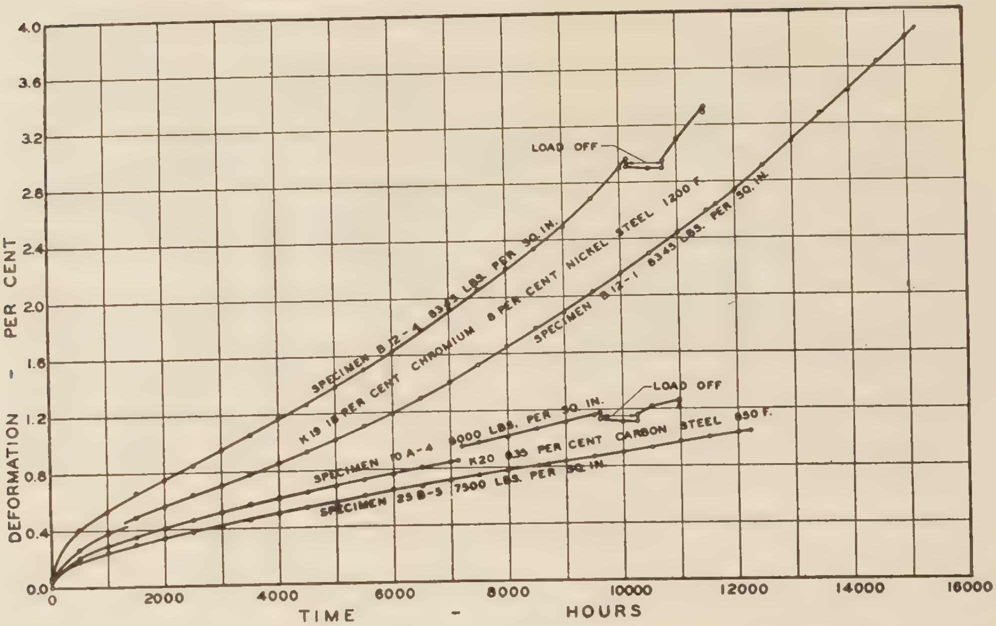


Fig. 5 Time-Deformation Curves for 18 Cr 8 Ni Steel K19 at 1200 F and 0.35 C Steel K20 at 850 F

ference would have increased rapidly if the test period had been further prolonged.

For specimen 25B-5, the extrapolated value at 12,000 hr would be about 1.31 per cent, whereas the decreasing rate since the start of the test has caused an actual deformation of about 1.03 per cent or about 21.5 per cent lower than the value obtained by extrapolation.

For specimen 10A-4, which has been discontinued at the shorter time of 9617 hr, the extrapolated value at 9500 hr would be about 1.30 per cent as compared with the observed actual value of 1.06 per cent, about 18.5 per cent lower than the value obtained by extrapolation.

Hence extrapolation from the 2000-hr test-period data in the case of the 18 Cr 8 Ni steel loaded to 8345 lb per sq in. at 1200 F leads to error which increases in magnitude as the time is increased.

But extrapolation from the 2000-hr test period in the case of the 0.35 per cent carbon steel loaded to 7500 lb per sq in. at 850 F leads to differences on the conservative side.

Since the rate is practically constant only continuation of the test period for this carbon steel will indicate whether the rate will further decrease or ultimately increase and cancel the favorable difference as compared with the extrapolated value.

These data confirm a statement in a previous report that for dependable extrapolations, knowledge of the strain-hardening characteristics of the materials is absolutely necessary.

Note in Fig. 5 the relatively small effect of unloading and reloading of specimens B12-4 and 10A-4.

Examination of Specimens After Creep Test

A, Surface. Figs. 6 and 7 show the external appearance (magnification about 1.75) of specimens B12-4 (18 Cr 8 Ni steel) and 10A-4 (0.35 per cent carbon steel) as removed from the creep-test units with the platinum measuring strips still in place.

Specimen B12-4 (Fig. 6) showed practically no scale and the discoloration was quite even. In this respect it differed from a previous specimen which was removed due to excessive rate of deformation and which showed a spotty appearance. The finger prints shown are the result of handling before the test was started.

Fig. 6 Specimen B12-4 18 Cr 8 Ni Steel, K19 After Removal From Creep Test of 11,467 Hr at 1200 F

Fig. 7 Specimen 10A-4 0.35 C Steel, K20 After Removal From Creep Test of 10,955 Hr at 850 F

Specimen 10A-4 (Fig. 7) showed a characteristic reddish iron-oxide scale which was cracking and splitting but there was evidence that it had been quite adherent until the deformation had caused the scale to part.

B, Structure. Fig. 8 shows the structure of a longitudinal

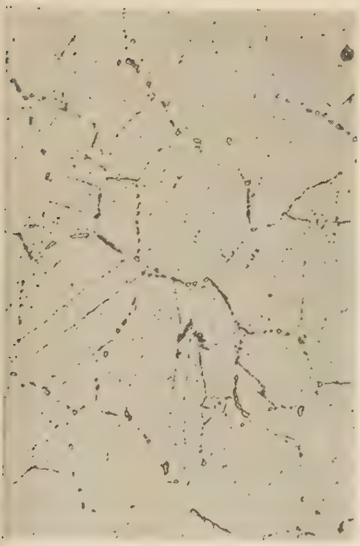


Fig. 8 Specimen B12-4 18 Cr 8 Ni Steel K19 After 11,467 Hr at 1200 F. Specimen Etched With Aqua Regia in Glycerin ×500

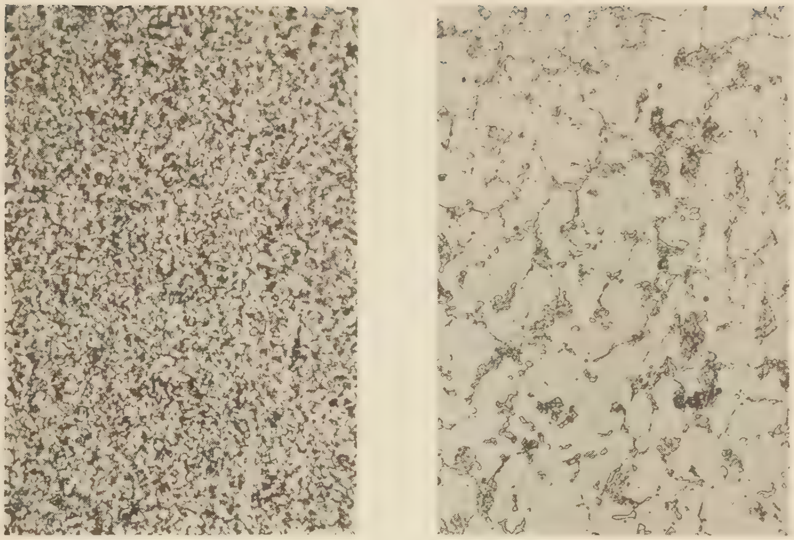


Fig. 9 Specimen 10 A-4, 0.35 C Steel K20 After 10,955 Hr at 850 F. Specimen Etched With 2 Per Cent Nital
(Left: Specimen ×100; right: Specimen ×500.)

section taken from the center of the creep-test specimen B12-4 (18 Cr 8 Ni steel) after test of 11,467 hr at 1200 F. Carbide precipitation has taken place in the grain boundaries, along twinning planes, and also within the grains themselves. Agglomeration of the carbide particles is also apparent. Careful examination of the specimen showed no difference in structure between the center and surface. No decarburization or intergranular parting or oxidation was evident.

Fig. 9 shows the structure of creep-test specimen 10A-4 (0.35 per cent carbon steel) after test of 10,955 hr at 850 F. Little change has taken place in this specimen. Possibly when compared with the structure as heat-treated the carbides are more spheroidized and agglomerated. There seemed to be no difference between the center and surface. Below the scale at the surface no decarburization was evident.

C, Impact Resistance. Two round Izod impact-test specimens (V notch) were machined from the reduced sections of creep-test specimens B12-4 and 10A-4.

The results obtained from the impact tests were as follows:

	Izod impact resistance, ft-lb As heat-treated	
18 Cr 8 Ni steel K19.......	101–107	B12-4 (11,467 hr at 1200 F) 50–58
0.35 per cent carbon steel K20....................	48–55	10A-4 (10,955 hr at 850 F) 54–55

While the impact resistance of the 18 Cr 8 Ni steel specimen B12-1 has dropped considerably from the value as heat-treated, a final Izod impact resistance of 50–58 ft-lb is usually taken as indicating ample toughness for any practical purpose.

Since the metallographic examination of the 0.35 per cent carbon-steel specimen 10A-4 showed but little change in structure during the creep test the lack of change in impact resistance is consistent with the structure.

Conclusions

The long-time creep tests on the 18 Cr 8 Ni steel at 8345 lb per sq in. at 1200 F show increasing rates of creep, thereby increasing the difference between the actual deformations measured and the value obtained by extrapolation from the 2000-hr test period.

The long-time creep tests on the 0.35 per cent carbon steel at 8000 and 7500 lb per sq in. continue to indicate extrapolation from the 2000-hr period conservative as compared with the actual deformation measured. It is obvious that without knowledge of the strain-hardening characteristics of a given steel, quantitative extrapolation from a single creep test, even of 2000-hr duration, is unlikely to be accurate. A family of creep curves from which may be deduced the loads and temperatures at which the curves change from the type that ultimately shows an increased rate of flow to that which ultimately shows a decrease, or some other method of determining the ultimate strain-hardening properties for different loads and temperatures, is necessary for complete evaluation.

Experiments on both steels on unloading, holding at temperature with zero load, reloading, and again unloading, indicate that practically all of the deformation subsequent to that measured upon application of the load at the start of the test is permanent and not recoverable.

Examination of an 18 Cr 8 Ni steel specimen after creep test shows carbide precipitation and agglomeration but impact tests, although indicating a reduction from the impact resistance as heat-treated, still indicate a satisfactory toughness.

Examination of a 0.35 per cent carbon-steel specimen after creep test showed little change in either structure or impact resistance from the heat-treated condition.

Constant Strain-Rate Tests on 0.35 C Steel K20 at 850 F

By A. NÁDAI[1] and E. A. DAVIS,[2] EAST PITTSBURGH, PA.

Introduction

IN CONTINUATION of the program of accelerated tests on the effect of the speed of deformation upon the yield stress of metals at elevated temperatures, constant strain-rate tests were made in tension on a 0.35 per cent carbon steel at 850 F. This is part of a testing program carried out at the Westinghouse Research Laboratories for several years on the creep and plastic flow of metals. The constant strain-rate tests to be reported briefly here were made for various reasons. One was to extend the range of speeds of deformation over a much wider scope than is usually found in the standard long-time tensile creep tests made at elevated temperatures. In the ordinary creep test, the load is kept constant and the range of speeds of deformation is confined to comparatively small velocities of stretching, so that tests must run for a long time. The usual time is three months with creep rates of the order of 10^{-8} in. per in. per hr or approximately 0.01 per cent deformation per year. In the constant strain-rate tests, strain rates about a thousand million times larger can be applied or of the order of 10 in. per in. per hour. A second reason for making such tests is that they can be carried out in a comparatively simple manner, and when properly analyzed may furnish information which can be utilized to predict the behavior of metals in the range of the slow rates of flow found in the ordinary creep tests made under constant stress. A third and important reason for making tensile tests under controlled rapid strain rates is that a few tests of this short duration together with one or two long-time tests reduces the time required for a determination of the relation of stress to velocity of deformation (the creep laws). It is realized that certain conditions cannot be reproduced by shortening the time of testing from several months to a few hours or days. It must, however, be said that the effect of prolonged exposure of a metal to high temperature, upon the mechanical properties could be determined by making short mechanical tests from time to time during the heating process. In other words, samples of a metal which have been kept at elevated temperature over the required long periods of time when subsequently tested in rapid tests, show the principal effects.

[1] Research Laboratories, Westinghouse Elec. & Mfg. Co. Mem. A.S.M.E. Dr. Nádai was formerly professor of applied mechanics of the University of Göttingen in Germany, and since March, 1929, he has been connected with the research laboratories of the Westinghouse Company and with the graduate school of the University of Pittsburgh.

[2] Research Laboratories, Westinghouse Electric & Manufacturing Co. Mr. Davis was graduated from the University of Pittsburgh in 1932 with the degree of B.S. in mechanical engineering. He entered the employ of the Westinghouse Company in 1933 and in April, 1934, was transferred to the research laboratories.

Contributed by the A.S.M.E.-A.S.T.M. Joint Research Committee on the Effect of Temperature on the Properties of Metals, Subcommittee E of Committee 3, and presented at the Annual Meeting of The American Society of Mechanical Engineers, held in New York, N. Y., November 30 to December 4, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until September 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

It is probable that the changes in the internal structure of metals due to a long exposure to high temperatures under unfavorable conditions, such as the presence of corroding atmospheres, could be tested in this way.

In order to compare strain rates obtained from rapid tensile tests with those observed in ordinary long-time creep tests, N. L. Mochel, secretary of the A.S.T.M.-A.S.M.E. Joint Research Committee on Effect of Temperature on the Properties of Metals secured a lot of 0.35 per cent carbon steel from the Bethlehem Steel Company and made a portion of this steel available for the controlled strain-rate tests. According to the intention of the Joint Committee several cooperators were asked to run comparative long-time tensile creep tests of 1000 hr and also of a much longer duration.[3]

There was, therefore, offered a unique opportunity to correlate the entirely different method of rapid tests in which the speed was kept constant with the observations made at several laboratories where tests were run under constant stress.

Material

The material used was a 0.35 per cent carbon steel, which was received fully annealed.[4] A one-inch diameter bar of this material, marked 12 and 12B, was received from N. L. Mochel of the Westinghouse South Philadelphia Works. This bar, which was about seven feet long, was slightly bent at the middle but enough material was obtained from the straight ends to make five tensile-test specimens.

Testing Equipment—Test Pieces

These tests were run on the constant strain-rate apparatus built into a modified ten-ton Amsler testing machine.[5] The hydraulic drive of this machine was used only as a load indicator, and the testing bars were stretched at constant relative speeds of the heads by means of a screw mechanism, electrically driven by means of interchangeable-gear speed reducers. The speed range extended from one to 20,000 and from one to 10^8 when the long-time tests of Battelle were included in the comparison.

The shape of the test pieces is shown in Fig. 1. They had a four-inch gage length. The heating furnace had an overall length of twenty inches and was provided with a narrow window, five inches long through which the elongation was optically measured with two micrometer telescopes. The gage marks were made by spot welding small platimum ribbons on the side of the bar. The measurements were made by focusing two telescopes on the edges of these ribbons.

[3] Compare: Report of Joint Research Committee on the Effect of Temperature on the Properties of Metals, preprint No. 25, 1936, A.S.T.M., p. 17, Appendix II, containing the newest data on two long-time tests on 0.35 per cent carbon steel at 850 F of 9620 hr at 8000 lb per sq in. and of 8690 hr at 7500 lb per sq in., respectively. Creep curves are shown in Figs. 4 and 5 of this report submitted by H. C. Cross and F. B. Dahle, Battelle Institute, Columbus, Ohio.

[4] A full description of the material and its preparation is given in the Progress Report by Subgroup D on Short-Time Tensile Tests to the A.S.T.M.-A.S.M.E. Joint Research Committee on the Effect of Temperature on the Properties of Metals, Trans. A.S.M.E., 1936, vol. 58, page 97, RP-58-4.

[5] A description of the apparatus will be found in a paper soon to be published on constant strain-rate tests with stainless steel.

Four thermocouples were clamped on each test piece before it was put in the furnace. Two of these were on the gage length and one was on each shoulder. The temperature was adjusted until the four thermocouples agreed within one deg C. After the test was in progress, the temperature could be read only on the shoulders because the clamps at the gage-length positions became loose. The temperature was kept to within 2 deg of 850 F during the tests and throughout the comparatively short gage length of the test bars.

Test Results

Stress-strain curves, for various velocities, for these tests are plotted as shown in Fig. 2. Fig. 3 shows the first portion of them corrected for reduction of area. It can be seen that the yield stress changes quite considerably for a given change in speed; that is, the material is already quite sensitive to speed changes at 850 F. This steel was not very strong and started to deform plastically at rather low stresses, but was exceptionally suitable for an investigation of the effect of the speed of deformation at this temperature. It can be noticed that the material is

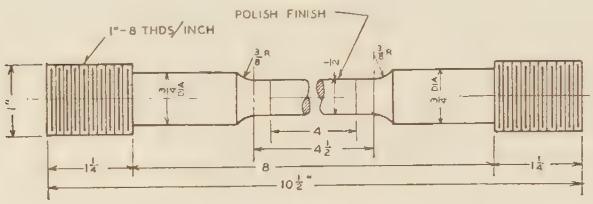


Fig. 1 Tension Test Piece

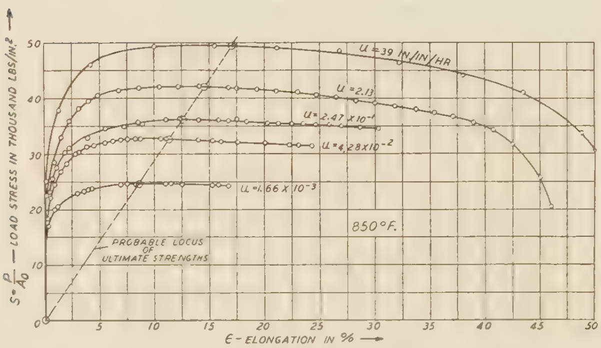


Fig. 2 Stress-Strain Diagrams for 0.35 C Steel K20 Taken at Constant Strain Rates. $u = d\epsilon/dt$ = Constant

still in the strain-hardening range. The ultimate strength was not attained until the strain reached about ten per cent, while in some previous tests on a twelve per cent chromium steel, the ultimate strength occurred at about three per cent strain at the same temperature.

Fig. 4 shows how the yield stress σ changes with the plastic-strain rate $u'' = d\epsilon''/dt$, ϵ'' = plastic strain. The points to the right of $u'' = 10^{-3}$ represent the tests made in this investigation at the Westinghouse research laboratories. Each line represents the relation between stress and speed of deformation for a given amount of plastic deformation. The four points to the left represent the tests made on this same material at the Battelle Memorial Institute and reported by Cross and Dahle. These four points were obtained by reading the speed of deformation at one-half per cent strain from Figs. 6, 7, and 8 of the Cross and Dahle paper.[6]

[6] "Long-Time Creep Tests of 18 Cr 8 Ni Steel and 0.35 Per Cent Carbon Steel," by H. C. Cross and F. B. Dahle, Trans. A.S.M.E., vol. 58, 1936, paper RP-58-3, p. 91.

Discussion of Test Results

Since these tests are designated as constant-rate tests, it might be well to consider what is meant by such a test. In dealing with large deformations or with creep phenomena, there are three

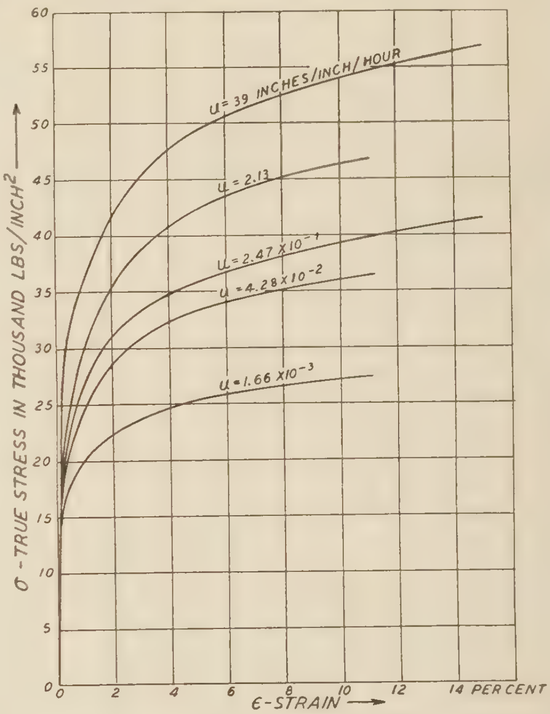


Fig. 3 Stress-Strain Curves for 0.35 C Steel K20 at $u = d\epsilon/dt$ = Constant, 850 F

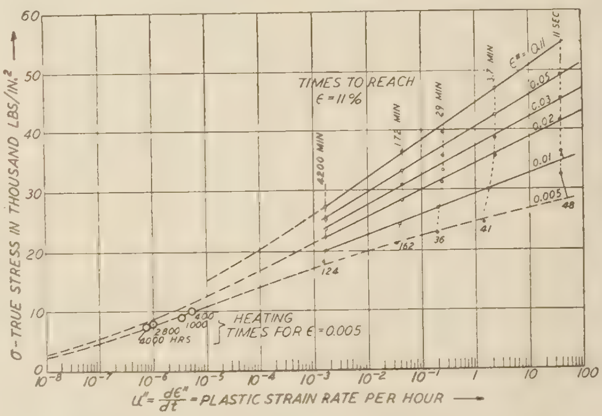


Fig. 4 Stress-Strain Rate Curves for 0.35 C Steel K20 at 850 F

strains that must be considered; the total ϵ, the elastic ϵ', and the plastic ϵ'', which are related by the expression

$$\epsilon = \epsilon' + \epsilon'' = \frac{\sigma}{E} + \epsilon''$$

There are also three corresponding strain rates given by u, u', u'' or

$$u = \frac{\partial \epsilon}{\partial t} = \frac{\partial \epsilon'}{\partial t} + \frac{\partial \epsilon''}{\partial t} = \frac{1}{E}\frac{\partial \sigma}{\partial t} + u''$$

The ideal constant rate test would be one in which the plastic strain rate, u'' was kept constant, but in actual testing with the equipment available, the best that can be hoped for is to keep the total strain rate u constant. It was found when this was tried that the rate u did not approach a constant value until the bar was stretched plastically about one-half per cent. This lag is due to the elasticity of the parts of the testing machine and probably to some looseness in the grips and heads. It is only toward the latter part of the test, where the load is increasing slowly, that a constant plastic-strain-rate test is realized. In Fig. 4, a constant plastic-strain rate would be represented by a vertical line through the curves. In the actual test u was constant, not u'', therefore, the vertical dotted lines joining the points of any one test tend to curve to the left at small strains, thus indicating lower plastic-strain rates for the first part of the tests.

In Fig. 4, the points representing a given amount of plastic strain, ϵ'' = constant are very close to a straight line. This would mean that the value of σ_0 in the logarithmetic speed equation, $\sigma = \sigma_0\left(1 + ln\frac{u''}{u_0}\right)$, is a constant over the range of speeds used in these tests. At lower strain rates, u'', these lines cannot remain straight and must show their convex side toward the abscissa axis. From similar tests made with stainless steel at 850 F, it was evident that they become flatter at still larger strain rates than those indicated in Fig. 4. This seems to be the general behavior for nonaging metals. In Fig. 4 the line for $\epsilon'' = 1/2$ per cent, is slightly curved. This departure from the straight line could be due to aging of the metal, for even though the strains are the same, the times required to reach these strains are very different. In order to check whether aging had an effect, a block of the 0.35 carbon steel was kept at 850 F without stress for seven months. The hardness was measured periodically on a Vickers hardness machine, but the change was within the accuracy of the machine, so that practically no change in hardness or aging was noticed in that time.

One thing of importance that might be noted is the fact that if any one of the points for the creep tests be connected by a continuous curve (here it was approximately a straight line) with a point for one of the rapid tests, the stress-strain rate relationship would be given almost as accurately as it could be determined from the four long-time creep tests. For obtaining design data for a material, it would not require the need of as much long-time test equipment as heretofore used, because one single long-time test would perhaps permit one to locate the curve with the required accuracy. It seems from these tests, that the curve could be drawn with a sufficient degree of accuracy without having even one long-time test available, using only the points obtained at the rapid strain rates. It is noted that the shortest test had a duration of less than one minute, while the longest constant strain-rate test lasted four to five days.

Along the lowest curve corresponding to a plastic strain of $1/2$ per cent in Fig. 4, the *heating times* are inscribed in hours which elapsed from the beginning of a test until an elongation of $1/2$ per cent was reached. It is quite interesting to note that the point at $u'' = 10^{-6}$ with a heating time of 4000 hr (one-half year) taken from the report of Battelle Institute, fits perfectly well with the curve in which some of the points correspond to the short heating times of one and one-half days. Along the upper curve for ϵ'' = 11 per cent in Fig. 4, the testing times are shown (in minutes) to reach 11 per cent strain. They varied between 11 sec and 4200 min.

It must be noted, that when age hardening becomes pronounced in a metal, the extrapolation of the curves shown in Fig. 4 and defined by the rapid tests, into the region of the slow creep tests where the time of exposure to temperature increased quite considerably, needs further careful considerations.

Some information with regard to the numerical value of the important constant σ_0 appearing in the logarithmetical stress versus speed-of-strain formula covering the straight portion of the curves of Fig. 4 is of interest.

$$\sigma = \sigma_0 (1 + ln \left(\frac{u''}{u_0}\right)$$

(σ = yield stress, $u'' = d\epsilon''/dt$ = the plastic-strain rate, u_0, σ_0 = constants) σ_0 can be computed from the slopes of the straight portion of the inclined lines in Fig. 4. The values of the constant σ_0 for various amounts of strain hardening expressed through the plastic strains ϵ'' (such as for example $\epsilon'' = 1/2$, 1, 2, 3, 5, and 11 per cent) are plotted in Fig. 5. It must again be noted, that the value of the constant σ_0 depends upon the previous history of the material, as was observed in numerous creep tests made with copper.

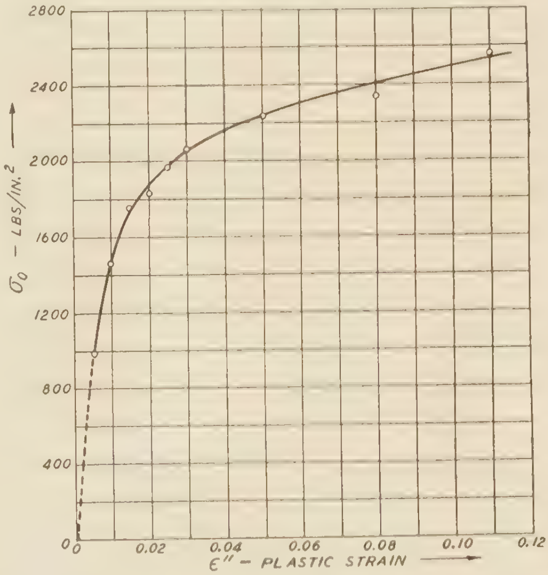


Fig. 5 Curve Showing Relations Between σ_0 and Plastic Strain for 0.35 C Steel at 850 F

Another interesting conclusion can be drawn from Fig. 2. It can be seen from this figure that the ultimate strength S_m decreases as the rate of strain u diminishes and at the same time the strain ϵ_m decreases, at which the maximum of the load S_m occurs. In Fig. 2, a dotted line has been drawn showing the probable locus of the points (ϵ_m, S_m). This curve seems to pass through the origin and is nearly a straight line having the equation

$$\epsilon_m = 3.5 \times 10^{-6}/S_m$$

Along this line are found the values of the strain ϵ_m at which the load maxima S_m occur at the various constant strain rates and at which the equilibrium in a tensile test made under these conditions becomes unstable.

Conclusion

When yield stress σ is plotted at a given strain ϵ'' against the logarithms of the speeds of stretching u'' within the range of speeds which were here considered the curves $\sigma = f(u'')$ for the 0.35 carbon steel approximate straight lines thus indicating that for the 0.35 carbon steel at 850 F

$$\sigma = \sigma_0\left(1 + ln\frac{u''}{u_0}\right)$$

For much smaller velocities these lines must approach asymptotically the value $\sigma = 0$.

When the speed of stretching was increased in the ratio of approximately 20,000 to 1 the yield stress was doubled. Fig. 2. The 0.35 carbon steel at 850 F was therefore exhibiting a very pronounced effect of the speed of deformation. Results obtained in these controlled, rapid strain-rate tests (of a duration of a few minutes, several hours, or a few days) checked well with results obtained in long-time creep tests made at Battelle Institute over periods of over 8000 hr duration.

A Relaxation Test on 0.35 C Steel K20

By ERNEST L. ROBINSON,[1] SCHENECTADY, N. Y.

IN CONNECTION with the cooperative program of high-temperature creep tests on 0.35 per cent carbon steel sponsored by the Joint Committee, the General Electric Company has run what it usually calls a "flow-rate test" and the results are presented herewith for their comparative value.

In conducting this type of test a relatively high initial stress is applied which corresponds to the initial tightening of a bolt, care being taken not to exceed a specified total extension. Initial creep is rapid and the applied load is reduced each time the total extension reaches the specified limit. The immediate reduction in elastic extension with each reduction of load permits further creep within the limit, and this creep takes place more and more slowly due both to the reduction of load and to the strengthening up of the material under whatever properties of initial strain hardening it may possess.

The test is a close approximation to what happens in a bolt in an unyielding flange. It might properly be called a test at constant extension as distinguished from the ordinary test at constant stress.

The 0.35 carbon steel, designated as K20 was manufactured by the Bethlehem Steel Company and distributed by the Joint Committee to cooperating laboratories. It has been fully described in the published reports sponsored by the Committee.

Fig. 1 shows the test results for 3670 hr at 850 F on the four specimens cut from bar 14 of this material. Specimen 14A1 was tested at 7500 lb per sq in. constant stress; 14A2 at 5500 lb per sq in. constant stress; 14A4 at 4000 lb per sq in. constant stress; and specimen 14A5 at 1.5 mils per in. constant extension.

Fig. 2 is the well-known log-log plot of stress vs. rate of creep. In this diagram line 1 represents the relaxation, or flow-rate test at constant extension, on bar 14A5. Line 2 represents the results of the several constant-stress tests at the end of 500 hr, and line 3 represents the same curves at the end of 3500 hr.

The differing slopes obtained in the two types of test are, of course, to be expected, since quite different conditions are represented. This brief statement is not intended to deal with the interpretation of the constant-stress results.

The fact that line 1 in Fig. 2 is straight over a long range of stresses leads to a simple mathematical representation of the results. It may also be said that this test is typical of hundreds of similar tests run by the General Electric Company on many materials and it is not an isolated case.

If X represents the total creep, S the residual stress at time t, E the modulus of elasticity, S_0 the nominal creep strength for a rate r_0 and n is the slope of line 1, the equation of the line is

$$r = (r_0/S_0^n)S^n = dX/dt$$

The condition of constant extension prescribed for the test is

$$X + (S/E) = S_1/E$$

in which S_1/E is the prescribed total extension and S_1 would be the initial stress in the bolt if it could be tightened instantly without any plastic extension during the application of the stress.

The two relations stated lead directly to the following expression between elapsed time, the nominal physical properties determined by the relaxation test, and the initial and residual stresses

$$t = \frac{S_0^n}{(n-1)\, r_0 E^n}\left[\left(\frac{E}{S}\right)^{n-1} - \left(\frac{E}{S_1}\right)^{n-1}\right]$$

Examination of this formula shows that it represents the difference of two time quantities. Ordinarily, and whenever the initial stress is relatively high, the second term will be found to be a very limited number of hours. If a stress-time curve is plotted, it will be found that after a few weeks or months a knee has been passed and further relaxation is very gradual, the few hours represented by the second term of the formula being of little significance.

Hence for year-long computations the formula may be written

$$t = \frac{S_0^n}{(n-1)\, r_0\, E\, S^{n-1}} \quad \text{or} \quad S = \sqrt[n-1]{\frac{S_0^n}{(n-1)\, r_0\, E\, t}}$$

It is interesting to note that the complete expression may be written in terms of extension by redefining X as the residual elastic extension and letting X_0 represent the elastic extension corresponding to the nominal creep strength S_0 and X_1 the specified limiting extension for the test thus

$$t = \frac{X_0^n}{(n-1)\, r_0}\left[\frac{1}{X^{n-1}} - \frac{1}{X_1^{n-1}}\right]$$

These expressions connecting time with stress or extension may be plotted to yield residual stress or total plastic extension, Fig. 3.

There are many reasons why relaxation tests at constant extension are useful and significant. Perhaps the least fundamental but a noteworthy reason is that behavior under a number of stresses is obtained from a single bar, while a battery of tests is required to give comprehensive information under a series of constant stresses. The step-down test is thus economical of furnace space.

The period of initial rapid creep is usually over in a few weeks and the knee of the relaxation curve passed, so that test results based on two or three months may be extended with confidence to a year or 10,000 hours. It is usually reasonable to suppose bolts may be retightened that often. In comparison with this, constant-stress tests may or may not give, in the same time period, results that can be extrapolated, depending on the stability of the material. However, it does not appear likely that relaxation tests can replace constant-stress tests. Both are necessary even if the latter do require longer time periods.

As a means of comparing the metallurgical behavior of materials under conditions approaching actual service the step-down test is good for several reasons. In the first place, the

[1] Turbine Engineering Department, General Electric Co. Mem. A.S.M.E. Mr. Robinson was graduated from the St. Lawrence University in 1911 and from the Harvard Graduate School of Applied Science in 1914 (M.C.E.). For three years he was engaged in construction work and the design of steel and reinforced-concrete structures in New York and in water-power engineering in New England. During the war he served in the Oise-Aisne offensive as First Lieutenant with the 302nd Engineers, U. S. A., and later as Captain and Adjutant of the 2nd Engineer Training Regiment. For the last 18 years he has been employed in his present capacity.

Contributed by the A.S.T.M.-A.S.M.E. Joint Research Committee on the Effect of Temperature on the Properties of Metals and presented at the Annual Meeting of The American Society of Mechanical Engineers held in New York, N. Y., November 30 to December 4, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until September 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

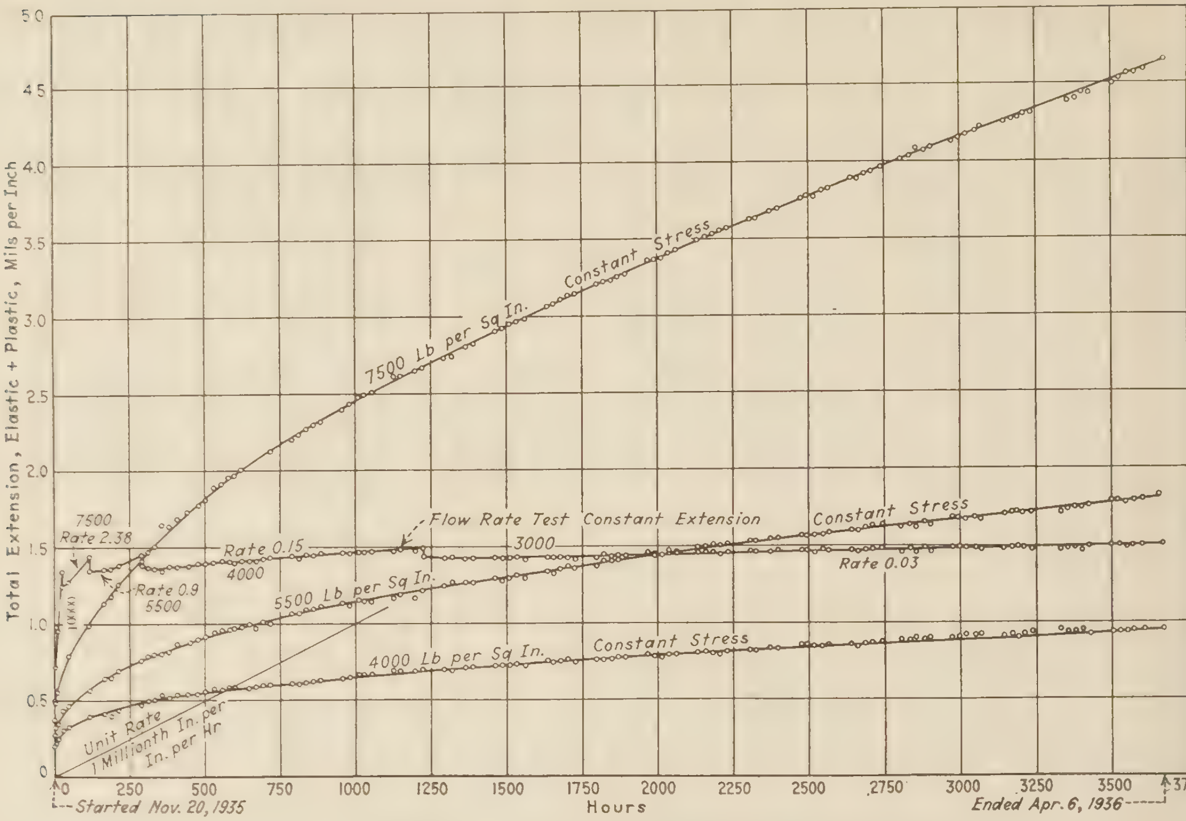


Fig. 1 Test Results on Four Specimens of 0.35 C Steel K20 at 850 F

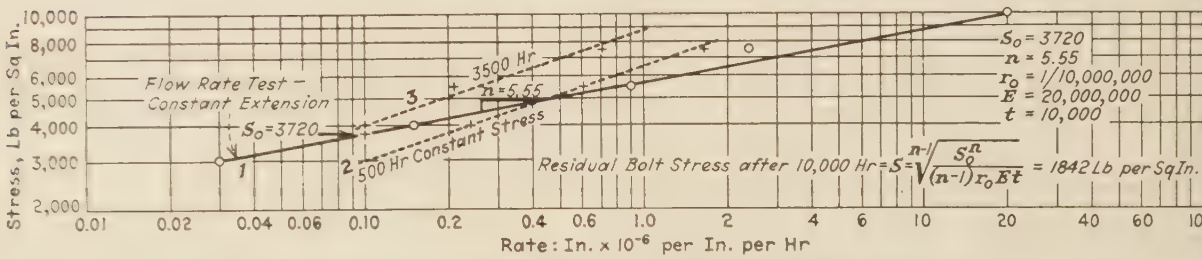


Fig. 2 Log-Log Plot of Stress Vs Rate of Creep on 0.35 C Steel K20 at 850 F

amount of stress relief is a direct measure of the initial creep effects. A material with a high rate of initial creep relaxes quickly and the residual stress is low. On the other hand, if the residual stress is high so that a bolt would stay tight, the test indicates that initial creep effects are small, the material getting its grip with a minimum of internal readjustment.

Furthermore, at the conclusion of the test the relation between the final stress and the corresponding rate of creep gives a good index of the long-time behavior of the material. The nominal creep strength corresponding to a specified rate describes that quality of the material while the residual stress after a specified time also includes initial effects.

Another real virtue of the relaxation test is that it definitely safeguards the test from any excessive strain-hardening effects. With constant-stress tests, if too big a stress is applied to a bar it will stretch beyond reason and the test will be largely wasted. Such a result is impossible with the step-down method, the strain-hardening effect being strictly limited by the method itself to values applicable to service.

Also the test gives information directly applicable to bolts in

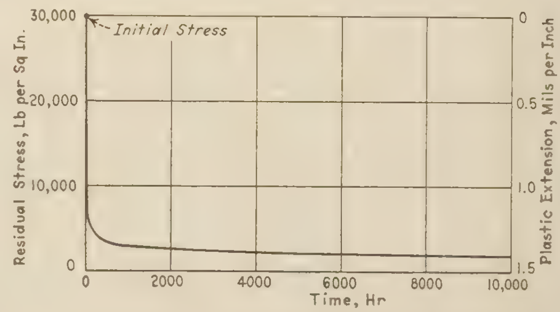


Fig. 3 Computed Bolt Performance, 0.35 C Steel K20 at 850 F

service or machine parts assembled with a shrinkage allowance.

It should be noted that when one half of such an assemby (the flange through which the bolt passes, for instance) is not substantially unyielding, the formula must be rewritten to take account of the actual arrangement. The modulus of elasticity must, of course, correspond with what the test indicates.

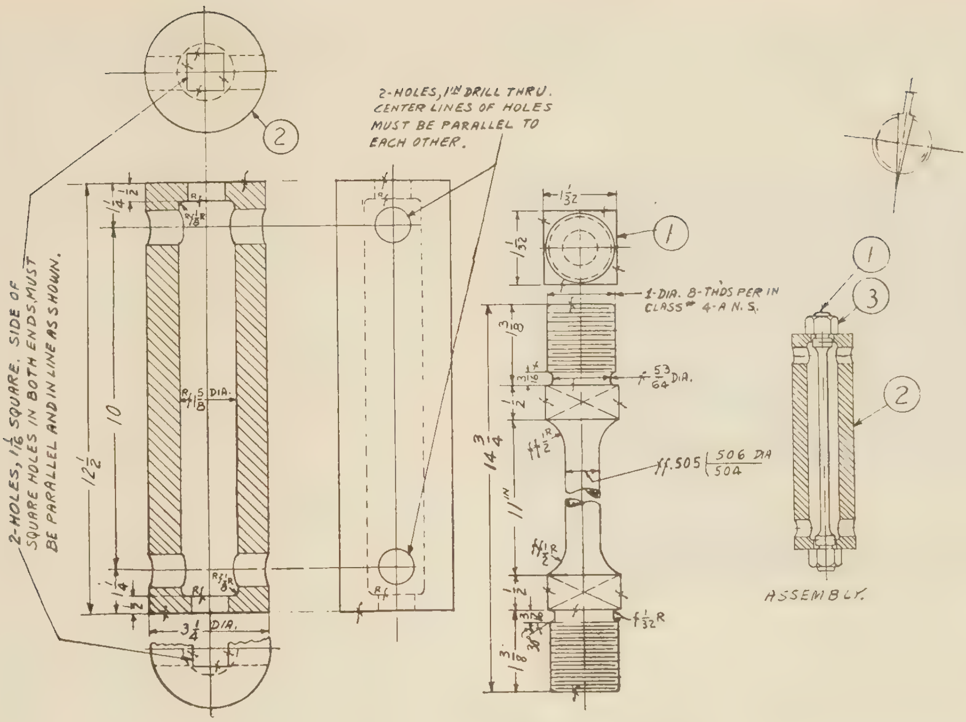


FIG. 1 TEST SPECIMEN, TEST BLOCK, AND ASSEMBLY

Relaxation Tests on 0.35 C Steel K20 at 850 F

BY N. L. MOCHEL,[1] PHILADELPHIA, PA.

INTRODUCTION

THE VARIOUS activities of the Joint Research Committee on Effect of Temperature on Properties of Metals have resulted in the collection of considerable data relative to the effect of high and low temperatures on a specially prepared 0.35 per cent carbon steel, known as material K 20. (See Appendix.) As these accumulated data offer a means of comparing the results secured by several methods of testing, it may be of interest and possible value to add to this accumulation the results obtained from a few simple relaxation tests. The writer has made use of such tests to judge the load-carrying ability of certain bolting steels.

TEST METHOD

Fig. 1 shows the test specimen, the test block, and the assembly. It will be noted that the test specimen is of 0.505 in. diam × 10 in. gage length, and that the threaded ends are made of sufficiently greater section to reduce greatly the stress at those points. Windows are provided in the test block, for purposes of measuring the specimen at the 10-in. gage length on two sides. A square hole is provided in the block and a square section on the specimen, at each end, to prevent twisting of the specimen when tightening the nuts. The gage lengths were fixed by 0.031-in. diam drilled holes rather than punch marks. It is of course necessary that the blocks be made of the same steel as the test specimens, in order to maintain uniform expansion.

Measurement was made with a 10-in. Whittemore strain gage, reading to $^{1}/_{10000}$ in. A standard 10-in. gage was modified by installing points of sufficient length to pass through the windows of the block, into the gage-length holes of the specimen. This instrument is held by two fingers and the thumb of each hand and applied to the work. It is not fastened to it. A standard reference gage is a part of the instrument.

A chart was prepared using the known modulus of elasticity, so that stress could be read directly from elastic or permanent deformation. The length of the specimen was first determined without stress. It was then inserted within the test block and the nuts screwed on by hand. With the test block held hori-

[1] Metallurgical Engineer, South Philadelphia Works, Westinghouse Electric & Manufacturing Co. Mr. Mochel was educated in Pittsburgh and was first employed in 1912 in the inspection department of what was then the Westinghouse Machine Company, later taking charge of the testing of materials. He continued in this capacity after the concern was merged with the Westinghouse Electric & Manufacturing Co. During the War he served with the rank of master engineer in the Engineer Corps of the United States Army in France. In 1920 he assumed his present duties.

Contributed by the A.S.M.E.-A.S.T.M. Joint Research Committee on the Effect of Temperature on the Properties of Steam and presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, held in New York, N. Y., November 30 to December 4, 1936.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until September 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

zontally in a vise, and with one set of windows up, a wrench was applied to one nut and the specimen stretched a predetermined amount. The stretch measurement was made through the top windows, and was then checked on the opposite side through the second set of windows. Fig. 2 shows a block, specimen, and the Whittemore gage.

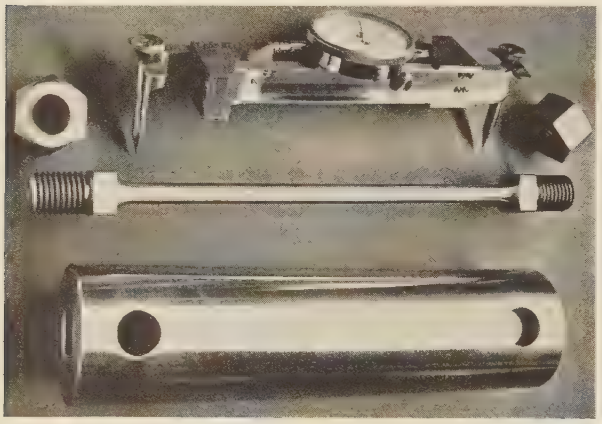


Fig. 2 Block, Specimen, and Whittemore Gage

The assembled blocks and specimens were then stood on end in a special holder provided for the purpose and placed in an electric furnace of cylindrical construction, which was equipped with copper lining, external resistance and double pyrometers arranged to allow the temperature to be closely controlled. Thermocouples were secured directly to the specimens.

Tests may be made in two ways: Specimens may be loaded at some common stress, and one or two specimens removed at desired intervals, cooled, unloaded, their permanent deformation determined, and the curve of relaxation against time plotted; specimens may be stressed in varying amounts and all subjected to temperature for the same length of time, then cooled, and permanent deformation determined. In either case, the measurements before and after the test are made cold, and the amount of permanent deformation indicates the relaxation that took place.

TABLE 1

Cycle hr	Specimen no.	Original stress	Residual stress, lb per sq in.: Side A	Side B	Average	Average for two
50	1	5000	4500	4500	4500	
	2	5000	3700	4100	3900	4200
	3	10000	6000	5900	5950	
	4	10000	5900	4100	5000	5475
	5	20000	4900	5900	5400	
	6	20000	4500	4500	4500	4950
100	1	5000	3600	3000	3300	
	2	5000	2300	2000	2150	2725
	3	10000	4100	5000	4550	
	4	10000	5400	4900	5150	4850
	5	20000	4000	4000	4000	
	6	20000	3300	3600	3450	3725
100	1	5000	2700	3000	2850	
	2	5000	3000	3000	3000	2925
	3	10000	3600	3900	3750	
	4	10000	5000	4800	4900	4325
	5	20000	4200	4200	4200	
	6	20000	3000	3000	3000	3600
250		5000	3600	3600	3600	
		5000	3600	3600	3600	3600
		10000	5000	5000	5000	
		10000	4100	4500	4300	4650
		20000	4100	4500	4300	
		20000	2300	2300	2300	3300
113	Overheated to 1070 F					
500	1	5000	3600	3600	3600	
	2	5000	3300	3300	3300	3450
	3	10000	6000	5700	5850	
	4	10000	5700	5700	5700	5775
	5	20000	4900	3300	4100	
	6	20000	4200	4600	4400	4250
1000	1	5000	2700	3300	3000	
	2	5000	3300	3600	3450	3225
	3	10000	5300	5000	5150	
	4	10000	5000	4700	4850	5000
	5	20000	3900	2300	3100	
	6	20000	4200	5300	4750	3925

Actual service conditions are duplicated, and it is believed that the tests have value from that standpoint. The advantage of being able to take all readings when the specimens are cold will be appreciated. These test methods also provide means for studying the galling of nuts, the use of thread lubricants, and the usefulness of penetrating oils before dismantling.

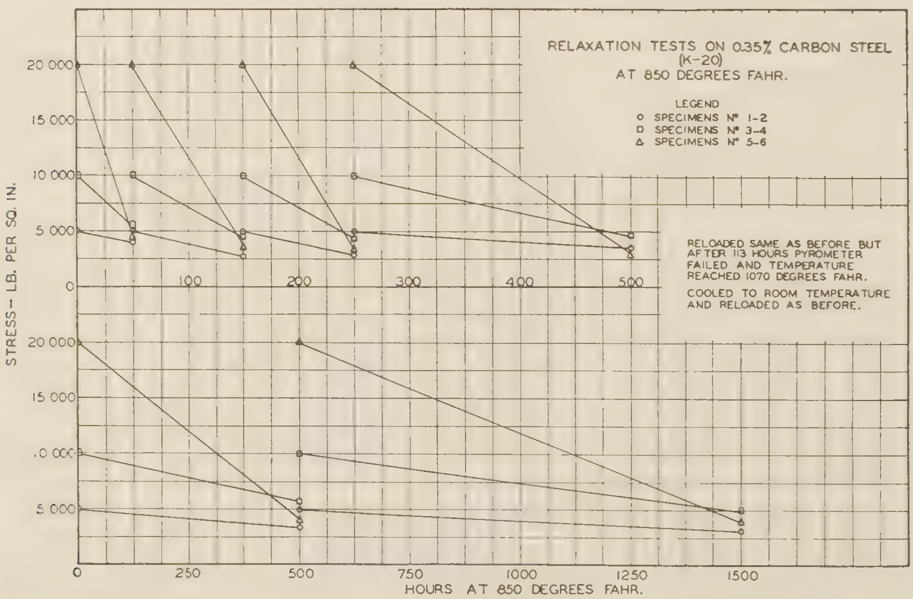


Fig. 3 Results of Relaxation Tests on 0.35 C Steel, Material K20 at 850 F, Using Average Values for Two Sides of Specimens

Tests Made on K20 Steel

Six specimens were prepared from bars K20–6 and K20–11 of the Joint Research Committee material.

Two specimens were stressed to 5000 lb per sq in., two to 10,000, and two to 20,000 lb per sq in. After a period of 50 hr at a temperature of 850 F they were cooled, and the permanent set of each determined. The specimens were then restressed to the same loads as before, held at temperature 100 hr, cooled, and measured. Another cycle of 100 hr and one of 250 hr followed, making a total of 500 hr at temperature.

During the next cycle, after 113 hours at temperature, a pyrometer failure permitted the temperature to reach 1070 F. The specimens were cooled, unloaded, and then reloaded to the same stresses as before.

Additional tests of 500 and 1000 hours were then run.

Fig. 3 shows the results of the tests in graphic form, using average values for two sides of two specimens. Detailed results are given in Table 1.

Discussion

A study of the detailed values shows variations in results beyond those considered good. Such variations have not been as great with other higher-strength steels similarly tested, and it is difficult at the moment to explain these differences. However, it is believed that the test has practical value, and indicates the load-carrying ability of this steel. The effect of the initially applied load is well indicated in the results.

Some few tests were made with a load of 30,000 lb per sq in., and these showed much lower residual stress and erratic results.

Appendix

A full description of the preparation and properties of this material is given in "Short-Time Tensile Tests at 850 F of the 0.35 Per Cent Carbon Steel, Material K20," Report of Subcommittee D of Committee 3, Transactions, A.S.M.E., vol. 58, 1936, paper RP-58-4, pp. 97–101. This report, as stated, covered the short-time tensile tests made on this material, by thirteen cooperating laboratories, to test the code for short-time tensile tests, A.S.T.M. Specification E21-34T.

An appendix to the above report dealt with impact tests at high temperatures on the same material, by two cooperators. Also fatigue tests were covered in this report.

Two progress reports made by the Joint Research Committee have dealt with extended creep tests on the same material:

"Long-Time Creep Tests of 18 Per Cent Chromium, 8 Per Cent Nickel Steel, and 0.35 Per Cent Carbon Steel." Report of sponsored researches at Battelle Memorial Institute, by H. C. Cross and F. B. Dahle, Trans., A.S.M.E., vol. 58, 1936, paper RP-58-3, pp. 91–96.

"Long-Time Creep Tests of 18 Cr 8 Ni Steel K19, and 0.35 C Steel K20." Report to the Joint Research Committee covering a sponsored research project carried out at Battelle Memorial Institute by H. C. Cross and J. G. Sowther. Trans. A.S.M.E., vol. 59, 1937, paper RP-59-5, pp. 441–445.

Appendix I of the 1936 Progress Report covered "General Summary and Comparison of Procedure and Results Obtained on Cooperative Study of Low-Temperature Impact Testing of 0.35 Per Cent Carbon Steel (K20)," Proceedings A.S.T.M., vol. 36, part 1, 1936, pp. 132–142.

Further reports of tests on this steel were made at the Annual Meeting of the A.S.M.E., December 1, 1936.

"Cooperative Creep Tests on 0.35 C Steel K20, at 850 F and 7500 Lb per Sq In." Progress report of the Joint Research Committee on Effect of Temperature on the Properties of Metals, Subcommittee E of Committee 3, C. L. Clark, chairman, Trans. A.S.M.E., vol. 59, 1937, paper RP-59-4, pp. 439–440.

"A Relaxation Test on 0.35 C Steel K20," by E. L. Robinson. Trans. A.S.M.E., vol. 59, 1937, paper RP-59-7, pp. 451–452.

"Relaxation Tests on 0.35 C Steel K20 at 850 F," by N. L. Mochel, Trans. A.S.M.E., vol. 59, 1937, paper RP-59-8, pp. 453–455.

"Constant-Strain-Rate Tests on 0.35 C Steel K20 at 850 F," by A. Nádai and E. A. Davis, Trans. A.S.M.E., vol. 59, 1937, paper RP-59-6, pp. 447–450.

Timber-Connector Construction

By PHILLIPS A. HAYWARD,[1] WASHINGTON, D. C.

The use of timber-connector construction has been acknowledged by authorities as one of the outstanding developments in modern-day use in wood construction. Up to the present time, over nine thousand structures, utilizing some three million board feet of lumber, have been built in which this improved system of timber construction was employed. Structures range all the way from small portable Civilian Conservation Corps camp buildings and low-cost homes, to all-wood radio towers, 326 ft high, and 700-ft timber highway bridges. Wood has repeatedly increased its standing as an engineering material through the use of timber connectors.

This paper tells of the introduction of timber connectors into the United States and gives an analysis of the various types and their possibilities in construction. Particular reference is made to the fact that through their use the strength of wood is increased approximately four times. Important projects in which timber connectors are used are discussed.

TIMBER connectors, recently introduced into American practice, give promise of revolutionizing structural design with timber and restoring its use for many purposes for which it has not been given consideration for a long time. When employed in roof and bridge trusses, diagonal bracing, and other construction requiring end connections of axially loaded members, wood has had its carrying capacity limited in the past by connection details and devices which at times would develop only about 20 per cent of the allowable working load of the members. With timber connectors it is usually feasible to realize in the connections more than 75 per cent of the allowable working load of the members, and the structural efficiency of the material is increased as much as 400 per cent over previous practice.

The expression, "timber connectors," includes a number of devices varying in type and function, practically all of which were invented and employed in Europe during the last two decades. Although American timber resources are far superior to those of the continental countries both in volume and quality, much more consideration is given there to structural use of this material, and timber is often imported from this country to be used in types of structures for which other materials are customarily used here.

With a view to making timber connectors available in the United States, the Department of Commerce, early in 1930, arranged with the various European firms manufacturing or selling these devices to ship a sufficient number of each type to this country for experimental purposes. During 1931 and 1932, tests of these sample connectors were carried on at the United States Forest Products Laboratory, at Madison, Wis., where safe working loads were recommended for each type when employed in the principal American structural species.

It was early recognized that these connectors possessed considerable advantage over the current types of timber-connection details, and in order to bring these advantages to the attention of potential users and to make the connectors generally available, the National Lumber Manufacturers Association, representing the organized lumber producers of the United States, undertook their manufacture and commercial distribution. The more promising of numerous devices were selected and developed in a range of sizes applicable to American standard timber sizes. A great amount of additional testing has been done to arrive at proper working loads for these new sizes in American species, and to afford necessary information on spacing, margins, and the influence of various special factors, such as timber density, conditions of exposure, angle of load to grain, and character of loading.

Three Types of Connectors

Three types of connectors were made commercially available about July, 1933, since which time their employment for structural purposes has increased rapidly. Several million connectors have so far been used in more than 9000 timber structures of many kinds. The United States government has used a great number of connectors in its CCC camp construction program, also on hydroelectric projects, and for various other purposes. State and city governments, public utilities, railroads, and large construction companies are employing connectors in increasing numbers.

The three types of connectors now commercially available are the toothed ring, Fig. 1, known in Europe as the alligator; the split ring, Fig. 2; and the shear plate, Fig. 3, also called the claw plate.

Toothed rings are sharp-toothed corrugated rings of 16-gage hot-rolled sheet steel. When they are to be used in a connection, the members are usually placed in their proper relative position and holes are bored for the bolts which hold the pieces in contact. The members are then lifted apart, toothed rings as specified are placed between them, usually concentric to the bolts, and the bolts are drawn tight, forcing the timbers together and imbedding the toothed rings in the adjacent faces. (See Fig. 4.)

This method of installation sometimes presents difficulties with very dry or dense timbers. In such cases, it is customary to use high-strength, alloy-steel bolts with large, ball-bearing washers and double-depth nuts to draw the timbers together, after which the high-strength bolt is replaced with an ordinary machine bolt. Various forms of clamps, presses, and jacks also are employed to embed toothed rings where the character of the work makes their use convenient. Toothed rings are most often employed where framed structures are to be built up with relatively thin members or where the use of motorized tools to cut grooves or daps for other types is not feasible.

Split-ring connectors are plain steel rings, rectangular in cross section, with a split or break in the perimeter, and are installed concentric to a bolt through the joint. When they are to be used in a joint the bolt holes are first bored according to the plans. Circular grooves one half the depth of the ring parallel to its axis

[1] Chief of the Forest Products Division, Bureau of Foreign and Domestic Commerce, Department of Commerce, in Washington. Mr. Hayward is a graduate of the New York State College of Forestry at Syracuse University, having specialized in lumber utilization and wood technology. For fifteen years, he has been actively associated with the lumber and timber-products industry, and allied fields, both in a technical and nontechnical capacity. As chief of technical research of the former National Committee on Wood Utilization, he assisted in the introduction and use of modern connectors in this country.

Contributed by the Wood Industries Division and presented at the Annual Meeting of The American Society of Mechanical Engineers held in New York, N. Y., December 2 to 6, 1935.

Discussion of this paper should be addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y., and will be accepted until September 10, 1937, for publication at a later date. Discussion received after the closing date will be returned.

are then cut with a special tool, concentric to the bolt holes in the adjacent surfaces of the timbers to be connected. The split ring is fitted in these grooves, one half its depth in each timber, and the joint is drawn tight with the bolt. (See Figs. 5 to 7.)

The shear-plate connector is a device for making connections between wood and steel members. Its toothed face is partly fitted and partly embedded in the timber until the opposite, or plane face is flush with the surface of the wood. The projecting

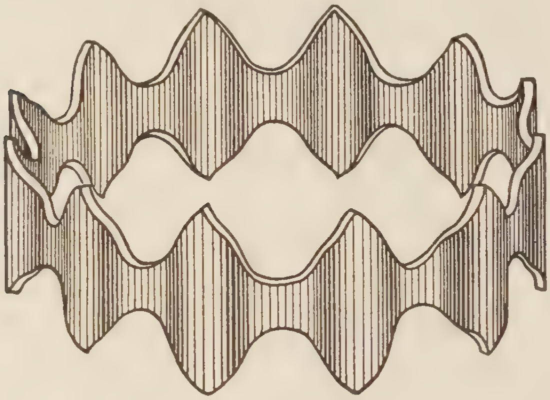


Fig. 1 Toothed-Ring Connector

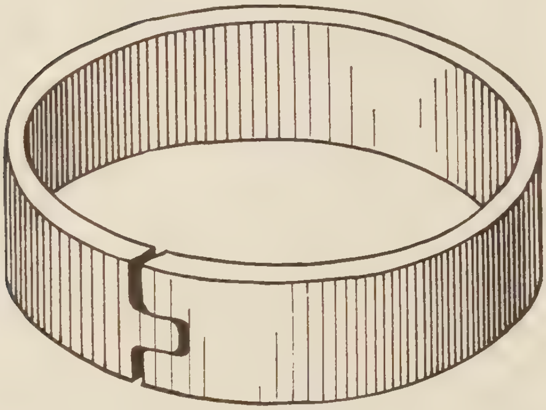


Fig. 2 Split-Ring Connector

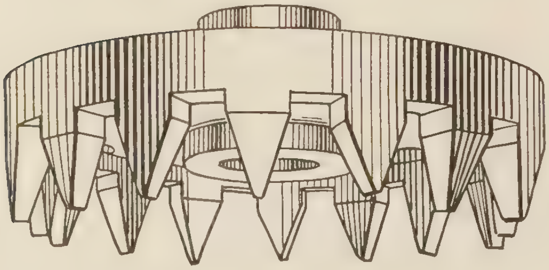


Fig. 3 Shear-Plate Connector

hub on this surface engages a hole in the steel shape or member to which connection is to be made. (See Fig. 8.)

Toothed and split rings are available commercially in several sizes, adapted to varying loads and to different sizes and thicknesses of timber. Shear plates at present are made in one size only.

Some recent work has been done on the solution of structural problems requiring the use of other types of timber connectors. A clamping plate has been developed for use between bridge ties and guard rails or stringers, between trestle caps and the tops of piles, and other points where lateral movement of one timber on another must be prevented. Flat and curved spike grids have been developed for use between bracing and piles or posts in marine structures and trestles. These connectors will soon be commercially available.

Possibilities of Timber Construction

The variety of uses to which connectors have been put is most remarkable, considering that they have been available commercially for only about two years. The extent to which timber construction employing them is likely to increase and spread depends considerably upon the extent to which architects, engineers, and builders are able to divest their minds of a widely disseminated misapprehension about timber construction and to view in an unbiased way the inherent possibilities of the material as influenced by: (1) Better and more dependable structural grades; (2)

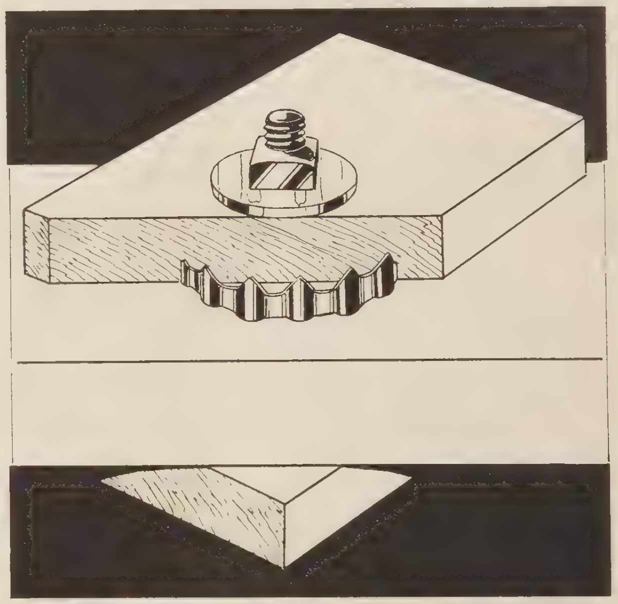


Fig. 4 Cutaway Piece in Assembly at Right Shows Toothed Ring With Half Its Depth Imbedded in Center Timber and Half Projecting Into Side Member

thorough and reliable preservative treatment where this is advisable; (3) stronger, simpler, and more economical designs available through the use of connectors.

Through the organized effort of the lumber manufacturers, working in collaboration with such groups as the American Society for Testing Materials, the American Railway Engineering Association, and the American Society of State Highway Officials, and with the close cooperation of interested government agencies, there has emerged during the last ten years a system of structural grading for lumber which admits of definite working stresses being assigned with confidence to each grade and species. The practice is rapidly increasing, of marking each piece so graded, at the mill, with its allowable unit stress in bending or compression. Where this is not done a certificate of inspection, guaranteeing the structural grade of the material, is usually obtainable upon request.

The advantages of preservative treatment of wood are increasingly recognized where the service conditions and the charac-

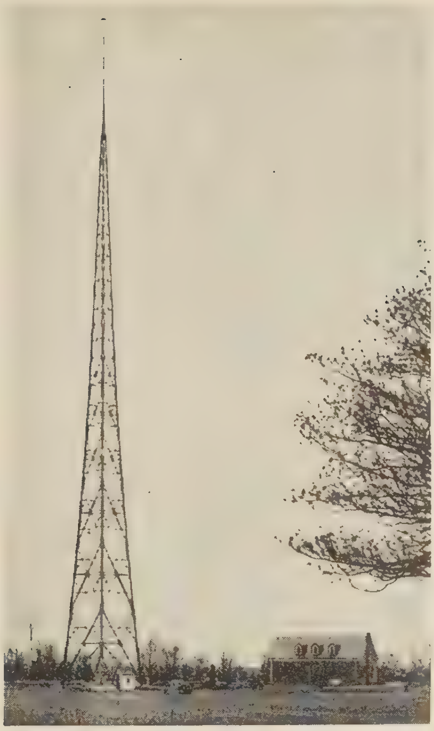


Fig. 5 An All-Wood 326-Ft Radio Broadcasting Tower at Richmond, Va.

(Made of longleaf southern yellow pine; joints framed with split rings. Reports indicate over 200 per cent increase in coverage as compared to steel-tower equipment and elimination of numerous "blind spots.")

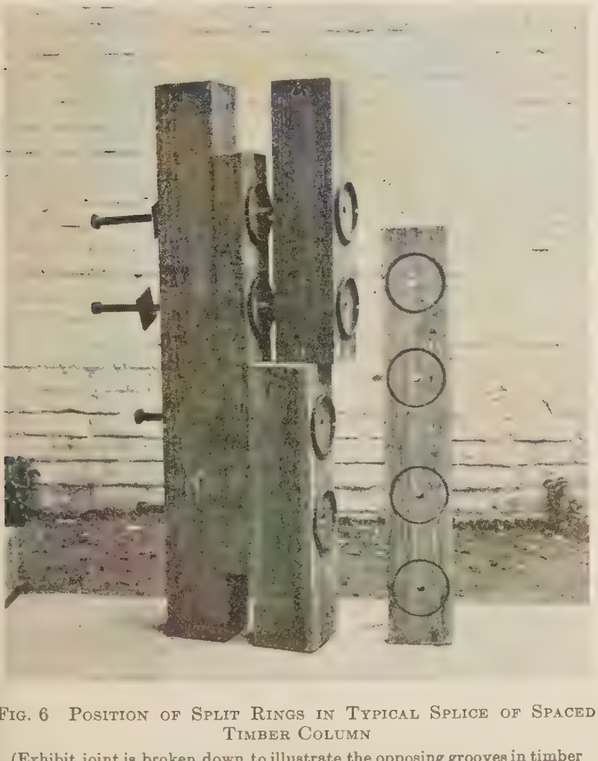


Fig. 6 Position of Split Rings in Typical Splice of Spaced Timber Column

(Exhibit joint is broken down to illustrate the opposing grooves in timber faces into which the rings fit and bear both against core and rim.)

ter of the material used make decay a hazard. There is accumulating, as time goes on, a greater volume of evidence as to the effectiveness of preservative treatment in certain fields where it has long been employed, from which results of its use in other situations can be predicted. Recognition is also being given to the greater service life of wood selected from the various species and grades available to meet special conditions

The foregoing with other aspects of wood utilization, constitute a vast volume of information not well-taught in technical and architectural schools and until recently not readily available in published literature. There have been issued recently, however,

Fig. 7 Cutting Grooves for Split Rings With Portable Drill

Fig. 8 Assembly of Steel Shear Plates Used in Foot of Radio Tower

a number of comprehensive booklets on wood utilization which should be in the hands of every student of the building professions and trades as well as those now practicing them.

Due to the lack of complete information on timber design and satisfactory control of quality, there has been a tendency in the past to penalize the material with unnecessarily low working stresses and to employ uneconomic sizes and grades. There also

has been an inclination to be content with less thorough inspection and supervision of fabrication and erection than is customary with other construction materials, and designers have tended to discount this prospect by overconservative designs. It is a truism, however, that lack of engineering design and supervision cannot be discounted safely even by the most conservative of working stresses, and the more recent tendency, stimulated by the introduction of timber connectors, is to apply these precautions in building to wood as well as other materials. Using principles of design and working stresses consistent with these precautions, it frequently develops that the same structural work is accomplished with a pound of timber as with a pound of steel.

Uses in Industry

Timber-connector construction is finding an increasing use in oil-industry structures. No oil derricks have as yet been built of this type, but several designs now in preparation indicate the feasibility of this type of structure. Numerous casing racks, oil-derrick foundation structures, and tank supports using connectors have been built in the Texas and Louisiana fields.

Several tank towers have been built of timber-connector construction, and this construction is particularly applicable in cases where heavy loads are to be supported, as timber by reason of its peculiar physical characteristics affords column load capacity in a very economical form.

Large numbers of connector-built roof trusses and roof arches are in use in spans ranging from the 20-ft width of the CCC camp buildings to 100- and 120-ft airplane hangars, garages, and ice-skating rinks. It is reported that over 80 linear miles of portable CCC camp buildings were built by the United States government during the last year in which an ingenious combination of portable roof panels and additional pieces were used to form Fink trusses connected with $2^1/_2$-in. split rings. The same type of building is now being adapted by the National Lumber Manufacturers Association to numerous other purposes, such as garages, farm buildings, summer camps, and low-cost dwellings.

The earliest timber-connector structure built in this country, so far as is known, was an 80-ft through-railway bridge for E-60 loading, constructed by the Weyerhaeuser interests on one of their logging railroads. This proved thoroughly satisfactory and subsequently another bridge of the same type was built. Since the general introduction of connectors into American practice, a considerable number of bridges have been built ranging from small temporary bridges of limited span and loading to a 180-ft arched bridge on the Pacific Coast Highway near Monterey, California, known as the Dolan Creek Bridge. This structure required 357,000 ft of timber and over 15,000 connectors. It was designed for the maximum highway loading. Timber-connector construction has also been utilized for stiffener trusses for suspension bridges in spans up to 209 ft.

The United States Army Engineers have employed timber connectors in building crib work for cofferdams on hydroelectric projects, both in the South and in the far West. Interesting examples of special uses include the use of toothed rings to stiffen the ribs of ice breakers built for the United States Coast Guard and the insertion of toothed rings between pile heads and caps in timber trestles, and between the ties and stringers and guard timbers in open and ballast deck trestles. Toothed rings are used for splicing, in joists and rafters in fire-damaged buildings, or where greater load capacity is required in a floor structure already in place. Large numbers of both types were used in strengthening and repairing California school buildings damaged by earthquakes in that state about a year ago. The United States government and several state governments have employed split-ring connectors in forest lookout towers ranging up to 100 ft in height, and one radio broadcasting tower 326 ft in height was constructed recently at Richmond, Virginia, entirely of timber-connector construction.

Prefabrication

One of the interesting developments in timber construction, made feasible by connectors, is the complete shop detailing of wood framing in the same fashion as is customary for steel fabrication. On numerous occasions, members shop-fabricated according to the usual details, have been transported several hundred miles and erected in the same fashion as is customary with steel.

One problem of the lumber industry in making the new construction development available generally to specifying consumers, architects, engineers, and builders, is the lack of fabricating concerns in the wood industry similar to those which operate steel-fabricating shops. The number of firms prepared to undertake such fabrication in timber is increasing rapidly, however, and there is also an increasing number of consulting engineers and architects throughout the country who are becoming familiar with the possibilities of timber-connector construction, so that in time arrangements for this type of service can be made as readily as is the case with steel.

Fabrication and Erection Costs

Experience on various jobs taken in conjunction with the known costs of timber connectors, hardware and suitable lumber indicate that the cost of connector structures in place, will not at the present price scale exceed 4 cents per pound and in many cases will fall much below that figure.

Acknowledgment

The author is greatly appreciative of the assistance given by Messrs. Frank Cartwright and Peter Landsem of the Timber Engineering Company, Washington, D. C. Credit is also given to this company for the illustrations shown in the accompanying text.

Discussion

Casting or Welding in Machine Design[1]

J. F. Lincoln.[2] Although the author's paper contains valuable and interesting information on the relative merits of castings and structures made from arc-welded steel, the writer believes he has not gone far enough into the subject and has thought in terms of what has occurred in this field rather than in terms of what should occur. The fundamentals of the problem are as follows:

Structural steel is two and one-half times as stiff and five times as strong as cast iron, yet it costs approximately one third as much per pound on the average. Arc welding makes it possible to join structural steel together at a very low cost so as to give a joint equal to the strength of the steel itself.

The writer is of the opinion that if a mechanical engineer with these facts at hand cannot produce structures in general very much cheaper with welded steel than with cast iron, then the difficulty is not with the process but rather with the engineer. At least 75 per cent of all castings which are now made can be redesigned using welded structural steel at a saving in cost and an improvement in the product. The method of accomplishing this is not obvious in all cases, but that is a problem with which the engineer must contend. Were it obvious, a great profession would be discarded.

Author's Closure

The author agrees with Mr. Lincoln that inasmuch as the modulus of elasticity of cast iron is approximately 12,000,000 and that of steel 30,000,000 the stiffness of steel for a given section is $2^1/_2$ times as much as that of cast iron. He realizes, however, that to increase the stiffness of a given section by $2^1/_2$ times requires an increase in depth of section of less than 40 per cent. As it may be entirely feasible in any given case to provide the required depth of section in cast iron to give the necessary stiffness, the advantage of the high modulus of elasticity of steel may not always be a controlling factor.

When we are considering structural steel and make the statement that steel is five times as strong as cast iron we must be thinking of ultimate strengths and furthermore, of a very high grade of structural steel and an extremely poor grade of cast iron. High-test cast iron is being produced regularly with several times the strength of the poor grade evidently meant in the five-to-one comparison. In machine design, where true surfaces and alignments must be maintained, we are interested in the yield point of the material rather than the ultimate strength. This figure is about 30,000 lb per sq in. for ordinary structural steel. The yield point and ultimate strength of any particular grade of cast iron are close together, which is another way of saying that cast iron is a brittle material. Ordinary grey cast iron has a strength of 20,000 to 25,000 lb per sq in. and the higher grades have a strength of 30,000, 40,000, and even more. It may transpire therefore that when the better grades of cast iron are used, they may be, from the standpoint of machine design, even stronger than ordinary structural steel.

Further, it is the author's feeling that it is passing too hurriedly over the matter of cost to state that structural steel costs approximately one third as much a pound as cast iron. The quantity price for structural steel may be roughly two cents a pound. According to this formula the average cost of cast-iron castings would be six cents a pound. Inasmuch as the cost of iron at the spout may be in the neighborhood of one cent a pound the cost per pound of the completed casting may easily be much less than six cents a pound if sections are heavy and the activity of the part is such as to justify high-grade pattern and foundry equipment. It should be borne in mind also that the two-cents-a-pound structural material must be cut to size, assembled with pieces in proper relation, and the welding operation performed before it is in form comparable to the completed casting. With the expense of these operations added, the whole cost divided by the number of pounds of the completed article will show a cost per pound considerably more than two cents and probably in the neighborhood of ten or twelve cents on the average. In addition to this, if machining operations are contemplated it will be found that the expense of machining the welded-steel structure will exceed the cost of machining the cast-iron casting.

Mechanical engineers undoubtedly have something yet to learn about the application of arc welding in the design of machine structures but the author feels constrained to submit that in perusing this study they will find necessary a much more detailed consideration of the relation of the casting and welding methods of fabrication than would be inferred from a reading of Mr. Lincoln's brief presentation of the "fundamentals" of the problem.

[1] Published as paper MSP-58-9, by J. L. Brown, in the October, 1936, issue of the A.S.M.E. Transactions.

[2] President, The Lincoln Electric Company, Cleveland, Ohio.

A Theory of Paper Drying[1]

M. A. Golrick, Jr.[2] The similarity between paper-drying and cloth-drying systems is apparent from a study of the theory and derivation of the equations presented by the authors. The application of drying cans to fabrics has been truly a rule of thumb development as far as the number for a given installation is concerned. In addition, the width has been generally standardized so that uneconomically wide cans are frequently used to dry narrow fabrics in plants having sufficient volume of these fabrics to warrant a more economical installation. The correct width of can as a single consideration is easily arrived at, but the entire balance is certainly worthy of study to have a better mathematical analysis than at present.

The suggestion of developing formulas for cloth drying, resulting from the development of the theory of paper drying as presented by the authors, holds interesting possibilities for further application to fabrics as well as paper. The closest analogy is that of cans being used to dry both materials, and the theory of moisture removal would be on a similar basis.

The outstanding difference between cloth and paper drying is that paper-drying systems use a felt to hold the paper fibers or the sheet of paper as it becomes dried to the surface of the drying cans. In fabric drying, the cloth is its own blanket. The only cloth-drying systems that use a blanket are the Palmer finishing machines. These are essentially much slower in drying cloth than the regular open textile can systems.

[1] Published as paper PRO-58-6, by E. Cowan and B. Cowan, in the November, 1936, issue of the A.S.M.E. Transactions.

[2] Plant Engineer and Production Manager, Dutchess Bleachery, Inc., Wappingers Falls, N. Y. Mem. A.S.M.E.

The effect of drying paper may have a similar effect of case hardening the fibers to that which it has on drying on cans certain textile fabrics, rayon in particular. The contact with a can surface gives a harshness to fibers which cannot be successfully removed in later processes. The rate of drying may have considerable influence on the degree of harshness, and possibly paper manufacturers have a better knowledge of the method of correcting this influence than textile finishers. Considerable investigation is being made along these lines at the present time.

The large difference in texture between paper and cloth would minimize the importance of the rate of steam escape from the sheet of paper which is the first factor X, that is, the maximum permissible rate of evaporation in pounds of water per square foot of sheet per hour. The structure of cloth is a series of threads in varying combinations of weaves but having openings, which distinguishes cloth from paper. Paper does not have its fibers assembled in the same manner as do cloth fibers or yarn, and this inherent difference might have considerable weight in considering its balance of the factor X in the formulas.

One other difference which is easily discernible is the greater variation of thickness of textile fabrics as compared with paper. The thickness of cloth of usual type may vary from 0.008 in. to novelty or waffle cloth of $^3/_8$ in. thickness. A further difference in the latter types of cloth as compared to paper would be the entire lack of uniform surface contact. In the case of fabrics such as corded or float fibers, it would only be the top fibers in direct contact for half the cans in the drying system. In exceptionally thick fabrics such as waffle cloth, only the top threads would have can contact on one half the cans, leaving an air space of 0.25 in. or more between the can surface and the intervening fabric.

In general, the theory of paper drying might well be applied to cloth drying with due consideration to these previously mentioned factors. The cloth-drying systems in use have been expanded for such a variety of fabrics that in most cases the customer has specified the number of cans or cylinders and has been content with the result. As in paper drying, the control of speed and steam pressure has generally sufficed for practical purposes. Investigation of this theory of paper drying as applied to cloth may indicate other factors of interest to paper manufacture.

A lack of complete knowledge of the paper industry and its problems prevents a more extended discussion along these lines. However, it is hoped that these suggestions will stimulate discussion and bring about suggestions not only on paper drying but also on textile drying. Rule-of-thumb methods should be replaced with definite formulas and the authors have taken a constructive step in the right direction.

Welding Design[1]

H. C. Perkins.[2] The author describes a very interesting application of the principles of elementary strength of materials to a relatively new field. He makes it clear that the critical stress usually occurs at the minimum or throat section of a fillet weld, and that to a first approximation this critical stress may be regarded as uniformly distributed, or in cases such as bending of a fillet weld where a second approximation is required, the stress may be regarded as proportionally distributed. He also states that one of the first principles in the design of fillet welds is the "generally accepted assumption" that whenever possible "the stress on a throat section is principally a normal tensile stress."

[1] Published as paper MSP-58-1, by Charles H. Jennings, in the October, 1936, issue of the A.S.M.E. Transactions.

[2] Assistant Professor in Mechanics, Sibley School of Mechanical Engineering, Cornell University, Ithaca, N. Y. Mem. A.S.M.E.

These assumptions are generally consistent with those found in elementary texts on strength-of-materials, but the methods by which the author converts these assumptions into design formulas do not always conform to the fundamental principles taught in such texts.

Consider, for example, the derivation of the author's Equation [3] for stress at the throat section of the transverse fillet welds shown in Fig. 4 of the paper. As shown in Fig. 1 of this discussion the action line of the load makes a 45-deg angle with the throat section so the ratio of the force P to the area $(0.707hl)$ of that section is certainly not a tensile stress. Such a procedure is wrong in principle and leads to an underestimate of the stress.

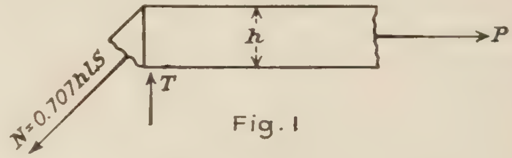


Fig. 1

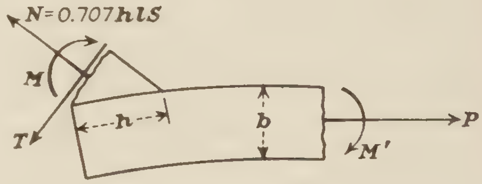


Fig. 2

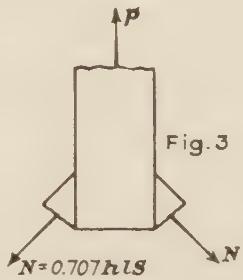


Fig. 3

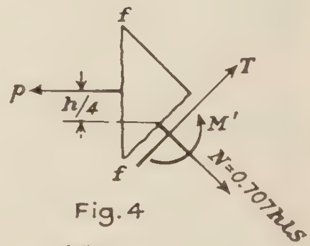


Fig. 4

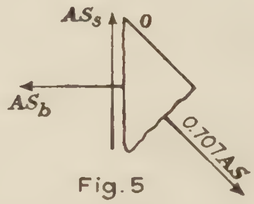


Fig. 5

Fig. 1 of this discussion shows the plate held in equilibrium by the load P, a tensile force $N = 0.707hlS$ normal to the throat section, and a transverse pressure T between plates as described by the author. If the action line of T is near the end of the plate, as shown, these forces are sufficient to satisfy the equations of equilibrium, in which case the throat section may be regarded as free from bending and shear.

Summing components in the direction of P

$$P - 0.707(0.707hlS) = 0$$

or

$$S = \frac{2P}{hl} \qquad [1]$$

Stresses obtained by this equation are about 40 per cent greater than those obtained by the author's Equation [3].

The derivation of the author's Equation [6] for maximum unit tensile stress in the throat section of the fillet weld of Fig. 6a

of the paper again involves some doubtful approximations. In this case, there is a fillet weld on only one side of the plate so, as the author states, "a bending moment resulting from the joint eccentricity must be considered."

It is in estimating the amount of this moment that one difficulty arises. The load being eccentrically applied, both fillet and plate may be bent. The greater the moment M' carried by the plate, the smaller must be the moment M carried by the fillet.

If the plate is relatively stiff or is laterally supported against bending, the fillet will bend very little if at all, and approximately $M = 0$. The throat section will then be stressed in tension and shear only. The average unit tensile stress on that section may be calculated from Fig. 2 of this discussion by summing components parallel to N, that is

$$0.707\ hls - 0.707P = 0$$

or

$$S = \frac{P}{hl} \qquad [2]$$

Results obtained by Equation [2] of this discussion are about 40 per cent less than those obtained by the author's Equation [4] which he again derives by dividing the force P by the area of a section at 45 deg to its action line.

If the plate is slender and bends easily the fillet may carry practically all of the bending moment, and

$$M = P\left(\frac{b}{2} + \frac{h}{4}\right)$$

Below the yield stress, the corresponding bending stress, formulated in terms of the section modulus of the throat section

$$Z = \frac{(0.707h)^2}{6}\, l = \frac{h^2 l}{12}$$

is

$$S_b = \frac{12M}{h^2 l} = \frac{3P(2b + h)}{h^2 l} \qquad [3]$$

The maximum tensile stress is obtained by adding the stresses given by Equations [2] and [3] of this discussion, or

$$S = \frac{P}{hl} + \frac{3P(2b + h)}{h^2 l} = \frac{4P}{hl}\left(1 + \frac{3b}{2h}\right) \qquad [4]$$

Equation [4] of this discussion is not comparable with the author's Equation [6]. However, if it be assumed that the moment is divided between plate and fillet in an arbitrary manner, that is, $M' = Pb/2$ and $M = Ph/4$, then the maximum elastic stress on the throat section is approximated fairly well by the author's Equation [6]. Adding bending stress to the average unit tensile stress as given by Equation [2] of this discussion, then

$$S = \frac{P}{hl} + \frac{12}{h^2 l}\frac{Ph}{4} = \frac{4P}{hl} \qquad [5]$$

This expression gives elastic stresses about 17 per cent greater than the author's Equation [6] which he derives by assuming that all of the fillet has passed the yield point, and that the bending stress is therefore uniform rather than proportionally distributed. The assumption that the bending moment is divided between plate and fillet in such an arbitrary manner is not likely to be consistent with the facts, so it is surprising that the author's Equation [6] should agree at all with experimental results.

The author's derivation of his Equation [8] is another example of faulty procedure. Assuming as usual that throat sections are subjected primarily to normal tension, let Fig. 3 of this discussion represent the plate held in equilibrium by a tensile load P and by tensile forces $N = 0.707hlS$ normal to the throat sections. These forces are sufficient to satisfy the equations of equilibrium. Summing components in the direction of P

$$P - 2(0.707)0.707hlS = 0$$

or

$$S = \frac{P}{hl} \qquad [6]$$

Stresses obtained by this equation are about 40 per cent greater than those obtained by the author's Equation [8].

Again, if the welds of Fig. 9 of the paper be analyzed by the method indicated in Fig. 1 of this discussion, the results will be about 40 per cent greater than those given by Equations [9] and [10] of the paper, as shown by the two following equations

$$S = \frac{a}{b + a}\,\frac{2P}{hl} \qquad [7]$$

and

$$S = \frac{b}{b + a}\,\frac{2P}{hl} \qquad [8]$$

Methods of computing stress in transverse fillet-welded joints subjected to bending are as the author says, approximate. The formulas he derives may agree fairly well with experiment but it is unfortunate that those formulas do not follow logically from his assumptions. Consider particularly the author's Equation [16] for maximum normal stress on a throat section when the load is a bending couple M as shown in Fig. 12a of the paper. The author assumes that the moment M is counteracted by a couple composed of forces p acting at the centers of the vertical fusion zones of the welds, shown as ff in Fig. 4 of this discussion, and therefore the moment $M = p(b + h)$. The load p on one weld is therefore assumed to act as shown in Fig. 4 of this discussion, from which it follows that the throat sections are stressed in tension, shear, and bending as shown in the figure.

Summing components parallel to N in Fig. 4 of this discussion, solving for average unit tensile stress S_1 and substituting for p in terms of M, then

$$0.707hlS_1 - 0.707p = 0$$

$$S_1 = \frac{p}{hl} = \frac{M}{hl(b + h)} \qquad [9]$$

But the force p has a moment $M' = ph/4$ about the central axis of the throat section, corresponding to maximum bending stress

$$S_b = \frac{ph}{4}\,\frac{12}{h^2 l} = \frac{3M}{hl(b + h)} \qquad [10]$$

The maximum normal stress upon the throat section is then equal to the sum

$$S = S_1 + S_b = \frac{4M}{hl(b + h)} \qquad [11]$$

If the author's Equation [16] gives results in fair agreement with experiment, Equation [11] of this discussion, which yields results 180 per cent greater, will be considerably in error.

Lacking such agreement, the author's assumption that M is counteracted by forces p acting at the center of the vertical fusion zones must be abandoned. A more familiar type of calculation leads to a simpler result with fewer doubtful assumptions. The

section modulus of both fusion zones together, about the central axis of the plate is

$$\frac{I}{c} = \frac{(b + 2h)^3 l - b^3 l}{12 \frac{b + 2h}{2}} = bhl + \text{terms in } h^3, h^4, \text{etc.}$$

The corresponding maximum bending stress is

$$S_b = \frac{Mc}{I} = \frac{M}{bhl} \qquad [12]$$

The stress near the surface of the fillet must be a simple tension parallel to the surface so the bending stress S_b at the outer edge O of the fusion zone must be accompanied by an equal shearing stress $S_s = S_b$ as shown in Fig. 5 of this discussion. Summing components in the direction of S_b

$$AS_b - (0.707)(0.707)AS = 0$$

and solving for the normal tension S

$$S = 2S_b = \frac{2M}{bhl} \qquad [13]$$

which yields results about 40 per cent greater than the author's Equation [16]. The only difference in case the load is a force P, is in the substitution of PL for M, whence

$$S = \frac{2PL}{bhl} \qquad [14]$$

which yields results about 40 per cent greater than the author's Equation [18]. Equation [14] of this discussion is very much simpler in form than the author's Equation [18], and it has a better technical basis.

There are some interesting steps in the author's derivation of his Equation [21] for maximum normal stress in longitudinal fillet welds subjected to bending. In the first place the section modulus for an axis inclined to the section is an unusual idea. In the second place this procedure leads to numerically incorrect results. Proceeding along more familiar lines, the section modulus of the two fusion zones next the support is, for both zones together

$$\frac{I}{c} = \frac{2hl^2}{6} = \frac{hl^2}{3} \qquad [15]$$

corresponding to maximum unit bending stress

$$S_b = \frac{Mc}{I} = \frac{3PL}{hl^2} \qquad [16]$$

The stress near the surface of the fillet must be a simple tension S parallel to the surface, as shown in Fig. 5 of this discussion, accompanied by vertical shear (perpendicular to the plane of the figure). The bending stress S_b at the outer edge O of the fusion zone must be accompanied by an equal lateral shearing stress $S_s = S_b$ as shown in Fig. 5 of this discussion. Summing components in the direction of S_b and solving for the normal tension S as before

$$S = 2S_b = \frac{6PL}{hl^2} \qquad [17]$$

which yields results 40 per cent greater than the author's Equation [21].

The author's Equation [26] is derived from his Equations [16] and [21] in a very clever manner but, unfortunately, both of these equations are incorrect so Equation [26] is of doubtful value. It is probably better to proceed along familiar lines anyway. The section modulus of the fusion zone is

$$\frac{I}{c} = \frac{(b + 2H)^3(l + 2h) - b^3 l}{12 \frac{b + 2h}{2}}$$

If h be regarded as relatively small, this expression may be expanded and simplified by dropping terms in h^3 and h^4. Then

$$\frac{I}{c} = \frac{bh}{3}(3l + b + 4h) + \ldots$$

Using this value, the maximum bending stress on the fusion zone is

$$S_b = \frac{Mc}{I} = \frac{3M}{bh(3l + b + 4h)} \qquad [18]$$

Calculating the corresponding normal stress S from Fig. 5 of this discussion

$$S = 2S_b = \frac{6M}{bh(3l + b + 4h)} \qquad [19]$$

This Equation [19] is very much like the author's Equation [26] in form but yields results about 40 per cent greater.

The author's Equation [32] also yields results which are about 40 per cent in error. This is another case in which little is gained by departing from familiar methods of procedure. The section modulus about a diameter of a hollow circular section with an outside diameter $(D + 2h)$ and an inside diameter D, as shown in Fig. 15 of the paper, is

$$\frac{I}{c} = \frac{\pi}{32}\frac{(D + 2h)^4 - D^4}{(D + 2h)} = \frac{\pi Dh}{4}(D + h) + \ldots$$

The first term, alone, corresponds to the value used by the author.

The maximum bending stress on the fusion zone is then

$$S_b = \frac{Mc}{I} = \frac{4M}{\pi Dh(D + h)}$$

corresponding to normal stress S from Fig. 5 of this discussion, or

$$S = 2S_b = \frac{8M}{\pi Dh(D + h)} \qquad [20]$$

which yields results 40 per cent greater than the author's Equation [32].

The author's Equation [37] is derived from his Equation [3] which yields results 40 per cent too low. Therefore, Equation [37] of the paper should be corrected to read

$$S = \frac{2P}{2hl + h_1 l_1} \qquad [21]$$

To summarize the discussion, the writer recommends the following, after corresponding changes have been made in Figs. 19, 20, 21, and 22 of the paper:

For calculating stress in a lap joint with a single transverse weld, substitute the writer's Equation [1] for the autbor's Equation [3].

For calculating stresses in welds on one side of a plate in tension and in which bending is prevented, substitute the writer's Equation [2] for the author's Equation [4].

For calculating stresses in welds on one side of a plate in which bending is carried by the weld, substitute the writer's Equation [4] for the author's Equation [6].

For transverse welds on both sides of a plate in tension, substitute the writer's Equation [6] for the author's Equation [8].

For calculating stresses in double-welded lap joints, substitute the writer's Equation [7] for the author's Equation [9].

For double transverse welds in bending, substitute the writer's Equation [13] for the author's Equation [16], and also the writer's Equation [14] for the author's Equation [18].

For double longitudinal welds in bending, substitute the writer's Equation [17] for the author's Equation [21].

For transverse and longitudinal welds subject to bending, substitute the writer's Equation [19] for the author's [26].

For a ring weld at the end of a circular bar in bending, substitute the writer's Equation [20] for the author's Equation [32].

For butt weld with cover plates attached by transverse welds and subject to tension, substitute the writer's Equation [21] for the author's Equation [37].

Author's Closure

The author pointed out in the paper[1] that there was a surprising lack of agreement among authorities in regard to the proper method of making stress analyses. Also, he pointed out that many of the equations given were those that are now commonly accepted by the trade and that they were only approximate equations justified because of their fair agreement to actual test results. In other words, if the tensile strength of the weld metal is known, the ultimate strength of the welds, calculated from the formulas given, should give results approximately equal to the ultimate strength of the weld metal.

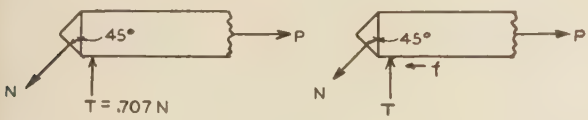


Fig. 6

Mr. Perkins has criticized the formulas in the writer's paper and has in turn developed formulas also open to criticism.

Referring to the determination of the stress in a simple fillet weld Mr. Perkins has used a free-body diagram, as shown in Fig. 6*a* of this discussion which assume the plates to be in contact. If there is a force T present, there must also be a friction force f present as shown in Fig. 6*b* of this discussion. The value of the friction force may vary over a wide range, depending upon the surface conditions of the plates. If the friction force is assumed to be $^1/_4\,T$, then the equation for the weld stress will be: $P = (T/4) + 0.707N$, where $T = 0.707N$. Therefore, $P = 0.707N\ (1.25)$, or $N = P/[(0.707)(1.25)]$. The stress $S = N/0.707hl = P/[(0.707)^2hl\ (1.25)]$, or

$$S = 1.6\ P/hl \qquad [22]$$

Equation [22] of this discussion is in closer agreement with Equation [7] of the paper than it is with Equation [1] of this discussion as given by Mr. Perkins.

Another method of analysis has been used by L. W. Schuster[3] which consists of resolving the force P into tangential and normal components, as shown in Fig. 7 of this discussion, and assuming the resultant principal stress at the weld throat to be the critical stress.[4] If it were assumed that the welded plates are not in contact with each other so that the force T, which is shown in Fig. 6 of this discussion, is not present (this case sometimes occurs in practice) then the stress at the weld throat will be

$$S = \frac{1.618\ P}{hl} \qquad [23]$$

This equation compares closely to Equation [22] of this discussion, and does not differ greatly from the conventional equation $S = 1.414\ P/hl$.

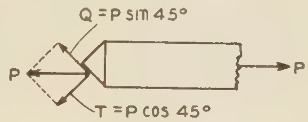


Fig. 7

As mentioned before, all of these equations are only approximations. Consequently, the choice as to which one to use depends upon their agreement with actual test results. Tests made on fillet welds deposited with bare type electrodes that produce weld metal with an ultimate strength of 55,000 lb per sq in. and 10 per cent elongation in 2 in. are given in Table 1 of this discussion.

TABLE 1 TENSILE TESTS ON FILLET WELDS

Size of welds	Ultimate load, lb 2P	Stress lb per sq in. $S = \frac{1.414P}{hl}$	$S = \frac{1.618P}{hl}$	$S = \frac{2P}{hl}$
$^1/_4 \times 2^1/_2$ in.	44600	50700	57800	71400
$^1/_4 \times 2^1/_2$ in.	42800	48400	55500	68500
$^1/_4 \times 2^1/_2$ in.	39500	44800	51200	68100
$^1/_4 \times 2^1/_2$ in.	47700	56400	64400	79500
$^1/_4 \times 2^1/_2$ in.	41200	46600	53200	65900
Average	...	49400	56400	69600
$^3/_8 \times 2^1/_4$ in.	60700	50900	58400	72000
$^3/_8 \times 2^1/_4$ in.	57800	48500	55500	68500
$^3/_8 \times 2^1/_4$ in.	56200	47100	53800	66500
$^3/_8 \times 2^1/_4$ in.	54800	45800	52500	65000
$^3/_8 \times 2^1/_4$ in.	60100	50400	57600	71300
Average	...	48500	55500	68700

Note: All welds had very good fusion.

From these data it is seen that the author's proposed equation $S = 1.414\ P/hl$ gives fairly good agreement, Mr. Perkins' equation $S = 2\ P/hl$ gives quite high results, while the third equation $S = 1.618\ P/hl$ gives the closest agreement.

The fact that the conventional equation $S = 1.414\ P/hl$ gives close agreement to test results and is used almost universally in this country for computing stresses in fillet welds there seems to be justification for its continued use, even though the third method discussed appears to be more accurate.

Considering the other equations discussed by Mr. Perkins it will be noted that although a different method of analysis was used in many cases the results obtained always varied by about 40 per cent. In other words, if a similar method had been used to analyze the simple fillet weld the results obtained in both cases would have been essentially the same.

The author greatly appreciates Mr. Perkins' discussion because it indicates that some serious thought is being given to the problem and it is only in this way that a standard method of calculating weld stresses can be developed.

[3] "British Engine, Boiler, and Electrical Ins. Co., Technical Report for 1928," by L. W. Schuster, pp. 26–30.

[4] "Computing Fillet Weld Stresses," by C. H. Jennings, *Welding*, vol. 2, February, 1931, pp. 101–104.

Experimental Determinations of the Flow Characteristics in the Volutes of Centrifugal Pumps[1]

A. J. Stepanoff.[2] The results of tests presented in this paper are of particular interest, because they were based on large-sized modern high-efficiency pumps. A great many previous publications on centrifugal pumps have dealt with such small obsolete designs that conclusions based on tests have been entirely mis-

[1] Published as paper HYD-58-4, by R. C. Binder and R. T. Knapp, in the November, 1936, issue of the A.S.M.E. Transactions.

[2] Assistant Chief Engineer, Byron Jackson Company, Berkeley, Calif. Mem. A.S.M.E.

leading, and certainly were of little interest to the commercial designer of centrifugal pumps or to the industry.

The writer does not agree with the authors in some of their analyses and conclusions. For instance, the explanation of two peaks in the velocity distribution across the volute at the impeller discharge by the pumping effect of the outside walls of the impeller shrouds, seems unreasonable, and the improvement of pump efficiency by such "energy pump" is hardly possible. It should be remembered that all low-velocity water in the space between the impeller and case walls, which is acted upon by the impeller shrouds, comes from high-velocity and high-pressure sections of the volute into the low-velocity and low-pressure region at the case wearing ring. Thus, no recovery of the velocity into pressure takes place, and hence there can be no question that circulation of water in the space between the impeller shrouds and pump case results in a net loss of energy.

Higher efficiency of pumps, with larger clearances between the case walls and impeller shrouds in modern pumps, is accounted for by the use of more efficient impeller profiles with less abrupt change in the direction of flow in the impeller, requiring wider volute cases. Also, it has been proved by special tests that the losses at the impeller discharge are smaller when discharging into a body of revolving water than against the stationary walls of the pump casing. The greater clearances between the case and impeller also have the advantage of the possibility of using several impellers of different widths and diameters in the same case.

As far as the disk-friction loss is concerned, Le Conte's[3] and Gibson's[4] tests tend to prove that this loss is greater with larger clearances.

The following explanation of the two peaks in the velocity distribution at the impeller discharge across the volute is suggested:

It has been pointed out by several investigators that in a centrifugal-pump impeller there is circulation within the impeller channel superimposed on the outward flow through the impeller. With nonviscous fluids, as a result of the impeller rotation, only relative circulation within the impeller cells will result, and no head will be produced. With actual liquids, the more this circulation is suppressed by the impeller walls and vanes, the higher is the head produced by the impeller. Thus, impellers with a greater number of vanes generate higher heads. Also, for the same impeller diameter and number of vanes, narrow impellers will develop a higher head than wide impellers. Since the centrifugal component of the total head is the same for all points of the same diameter, this extra head can be only in the form of kinetic energy. The two peaks in the velocity distribution at the impeller shrouds are caused by the stabilizing effect of the shrouds on the flow in the impeller, whereby the circulation within the impeller channel is suppressed to a greater degree at the shrouds than at the middle of the impeller.

As an illustration of this point of view, the writer can mention some tests performed at the plant of the Byron Jackson Company on double-suction, horizontally split pumps. One test was conducted on a 36 in. pump which had an impeller diameter of 42 in., and a width of 12.5 in. The other test was conducted on a 10-in. pump which had an impeller diameter of 11 in. and a width of 2.25 in. Both of these impellers had the middle impeller wall extended to the full diameter of the impeller. The velocity distribution across the volute had three clearly marked peaks. Evidently the middle peak cannot be explained by the pumping effect of the outside impeller shrouds.

[3] "Hydraulics," by Joseph N. Le Conte, McGraw-Hill Book Company, New York, N. Y., 1926, p. 333.

[4] "Hydraulics and Its Applications," by A. H. Gibson, D. Van Nostrand Company, Inc., New York, N. Y., 3d edition, 1925, p. 190.

The uniform velocity distribution between the impeller vanes, as shown in Fig. 10 and Fig. 14 of the paper, seems improbable, particularly for a low-capacity point, when a considerable portion of the power input is wasted in turbulence. In modern high-efficiency pumps, impeller-vane tips at the discharge are made nonactive, or are so shaped that no head is generated by this portion of the vanes, thus providing a short transition path from the impeller to the volute where velocity can equalize. However, there is sufficient evidence, such as impeller pitting, wear marks, and reliable pressure-distribution tests,[5] within the impeller channels, to indicate that there is more velocity variation within the impeller passages than was recorded in the authors' tests. The causes for possible inaccuracy of observation were pointed out by the authors.

(Discussion following was submitted jointly with the discussion of the paper by R. T. Knapp.[6])

G. F. Wislicenus.[7] The writer has had the good fortune to witness at close range part of the research work which has been reported by the authors and later has been able to observe how grateful the pump industry is for investigations of this type. This industry has been puzzled for considerable time about mechanical failures of centrifugal pumps such as broken shafts and excessive wear on stuffing boxes and wearing rings. In most of these cases it becomes apparent that the pump was operated under conditions which, according to results obtained at the laboratory of California Institute of Technology, would yield high unbalanced forces acting radially on the impeller. The remedy first tried for such conditions was the use of so-called twin volutes, i.e., two volutes starting at 180 deg. from each other. The splitting up of the waterways, however, tended to decrease the efficiency of the pump. The Worthington Pump & Machinery Corporation therefore introduced the principle of staggering volutes of multistage pumps which had the effect of reducing the effective bending moments to such an extent that their influence can be neglected.

This remedy, however, is of course not applicable to single-stage pumps, and it is in connection with the latter type of pumps where the investigations of the California Institute of Technology laboratory can be expected to have a lasting influence on the future designs, because these experiments eventually will yield a reliable basis for the numerical prediction of the magnitude and direction of such forces.

At the present time the problem of these forces appears to be the most important, but by no means the only one, for which the designer hopes to obtain an answer from the investigations at the California Institute of Technology. The velocity distribution in the volute is of much more general importance, and up to now the designer has been forced to make certain assumptions concerning this matter, the hypothetical character of which could not be doubted since the present state of hydrodynamics does not allow describing the flow conditions in a centrifugal pump by theoretical means. For example, it would seem very desirable to extend the investigations so as to cover the velocity distribution in radial sections through the volute as a function of the rate of discharge.

It is safe to say that the work described in the two preceding papers,[1,6] if considered as a whole, constitutes a complete

[5] "Fundamental Research on the Distribution of Water Pressure in a Centrifugal Pump Impeller," by S. Uchimaru, *The Journal of the Faculty of Engineering*, Tokyo Imperial University, Tokyo, Japan, vol. 16, no. 6, September, 1925, p. 157.

[6] "The Hydraulic-Machinery Laboratory at the California Institute of Technology," by R. T. Knapp, Trans. A.S.M.E., vol. 58, November, 1936, paper HYD-58-5, p. 663.

[7] Worthington Pump & Machinery Corp., Harrison, N. J. Jun. A.S.M.E.

success, and it is only to be hoped that it is but the beginning of further investigations of the same type. It is exactly this kind of research work which is most urgently needed by the designer, referring this time particularly to the increased accuracy of pump tests of the usual kind which reveal facts not detectable by ordinary test-stand experiments. Merely as an example the writer should like to call attention to the possibility of distinguishing clearly between the very first beginning of cavitation and the final cavitation breakdown. Furthermore, it is to be expected that many phases of the technique of measurement, as well as control of operating conditions which were newly developed at the California Institute of Technology, will serve as precedent for future developments in scientific as well as commercial test-stand practice.

Authors' Closure

The authors find it difficult to accept all of Dr. Stepanoff's alternate explanations of the experimental observations. In the first place, they fail to see the force of the argument tending to show the impossibility of a contribution to the useful work of the pump from the flow in the clearance spaces between the impeller and the case. For example, if a balance is made of the energy in the flow entering and leaving the clearance spaces across the cylindrical surface which passes through the measuring-tube stations, it will be found that the energy content of the outflow is greater than that of the inflow. Therefore, the conclusion appears inevitable that energy is delivered to the volute from these clearance spaces, irrespective of the previous history of the fluid which serves as the energy carrier. The authors do not intend to imply that this energy contribution to the volute is equal to that imparted by the impeller shrouds to the fluid in the clearance spaces, but merely wish to suggest that a small part of it may be delivered to the volute instead of being dissipated in friction within the clearance spaces themselves. Thus, as Dr. Stepanoff points out, the circulation of the fluid in these spaces must result in a net loss of energy. He has also called attention to several reasons why modern pumps with larger clearances have higher efficiencies. The authors simply propose that the circulation in the clearance spaces makes one additional contribution to this improvement.

Dr. Stepanoff refers to Le Conte's[3] and Gibson's[4] tests to show that the disk-friction loss itself should be greater with larger clearances. The authors feel that there is a possibility of a fallacy in the extrapolation of these tests to the performance of an actual centrifugal pump. In the disk-friction tests there is no possibility of utilizing any of the energy imparted to the fluid by the disk; therefore, it is all loss. In a centrifugal pump this is not necessarily so, since some of it may be converted to pressure energy in the volute. In this connection, it should not be forgotten that there are two steps necessary in the phenomenon of disk friction: First, the imparting of kinetic energy to the fluid by the rotating disk; and, second, the transformation of this mechanical energy into heat through fluid friction.

It would be easier to accept the writer's explanation of the double peak velocity distribution as its sole cause if it were not for the fact that the phenomenon apparently extends over a width greater than that of the impeller discharge, thus indicating that some of the flow must come from the clearance spaces. Also a detailed consideration of the relative exit angles show their distribution to be quite different from that which would be caused by a superimposed circulation within the impeller. On the other hand, there is no reason to suppose that this possible impeller circulation does not contribute substantially to the peaked distribution observed.

The authors agree with Dr. Stepanoff that the relatively uniform velocity distributions between the impeller vanes shown in Figs. 10 and 14 of the paper seemed improbable before the measurements were made. On the other hand, if all due allowance is made for possible experimental inaccuracies, it is still necessary to conclude that the velocity is comparatively constant during the time required for one impeller passage to pass a given measuring station. Dr. Stepanoff is particularly concerned by this condition for low-capacity conditions during which, as he states, a considerable portion of the power input is wasted in turbulence. The authors believe that if the indications of Fig. 18 of the paper are considered, the tremendous variation in flow in a given passage during one complete revolution will offer ample opportunity to dissipate the necessary amount of energy. They also believe that this variation of velocity with position must be taken into account when the experimental evidence of impeller pitting, wear marks, and pressure-distribution tests within the impeller channels are evaluated.

The authors agree with Dr. Wislicenus that it would be highly desirable to have available more extensive investigations on the velocity distribution in the volute and it is definitely planned to extend this work in the near future. It is felt that much remains to be done before the flow conditions in centrifugal pumps and tubines will be completely understood, and it is hoped that this laboratory will be of service in this field of hydrodynamics.

The Hydraulic-Machinery Laboratory at the California Institute of Technology[1]

Ed S. Smith, Jr.[2] The writer personally witnessed the operation of instruments in the laboratory described by the author. He congratulates all sharing the responsibility for the development of the laboratory and for having created a unique tool of unparalleled accuracy for its highly specialized purpose. It is urged that this same group create a second and smaller laboratory of similar design, but make it one that could be adapted to general rather than specialized use. Such a laboratory would be invaluable to industry as well as for research, but, to be of greatest usefulness, it should be located more centrally (with regard to industry) in the country. Its relatively small cost could be liquidated within a reasonable period.

A small dynamometer, say 50-hp rating, would be suitable for testing the more common sizes of pumps, hydraulic motors, and complete hydraulic power-transmission units, using a moderately viscous oil as the hydraulic medium. The cost of instruments should also be comparatively small since they would be substantial duplicates of those already developed. Such a laboratory would be especially useful for providing the data needed on power-transmission units having pumps or hydraulic motors of the rotary-piston, or gear, type.

These extremely flexible and efficient hydraulic power-transmission units occupy a key position in industry by bridging the gap between the efficient but continuously running, constant-speed a-c motor and equipment that must operate either at variable speeds or intermittently; they are used for presses, elevators, machine-tool drives, rudder controls, and servomotor drives generally, as well as for transporting the fluids themselves.

Although the overall efficiencies of hydraulic power-transmission units with modern pumps or hydraulic motors of the rotary-piston type are readily established or checked by field tests, it is the writer's belief that there are wide differences between the

[1] Published as paper HYD-58-5, by R. T. Knapp, in the November, 1936, issue of the A.S.M.E. Transactions.

[2] Hydraulic Engineer, C. J. Tagliabue Manufacturing Company, Brooklyn, N. Y. Mem. A.S.M.E.

relative efficiencies of pumps and hydraulic motors reported by various manufacturers; some reporting higher pump than motor efficiencies and others vice versa. While there is evident reason for a lower efficiency of a gear-type hydraulic motor than for the same unit used as a pump, this does not seem to justify the present reported differences between pump and motor with modern rotary-piston units making liberal use of antifriction bearings. From tests within the writer's experience, he considers that the probable cause of these discrepancies is the use of Bourdon-type pressure gages on such tests. These are generally chosen with a low enough maximum to give an open scale that facilitates accurate reading during the test period. With such a low maximum, gages are unduly sensitive to the continuous and high-frequency pressure pulsations inherent in these high-speed high-pressure piston-type units. Such gages are also as likely to be thrown out of calibration by severe shocks from surges when changing speeds as when starting and stopping. Since the use of pulsation-throttling devices may cause inaccurate gage indications, it seems necessary to use a gage, if of the Bourdon type, having a scale maximum of from two to three times the normal working pressure to be reasonably sure of having the initial gage calibration maintained during any test of reasonable duration. Also, the sturdier gage made for higher pressures is generally needed to stand the usually severe mechanical vibrations existing in such high-pressure transmissions. Even with such gages it is desirable to remove the stop peg at the scale zero or to shorten the hand enough so that it clears the peg when pressure suddenly drops from a high value.

Pressure-weighing scales, such as those in the laboratory at the California Institute of Technology, promise to make possible, perhaps for the first time, reliable and accurate tests of mechanical efficiencies of rotary-piston pumps and hydraulic motors. The equipment in the proposed laboratory should be built for working pressures up to at least 3000 lb per sq in., and have means for accurately measuring the heat removal necessary to maintain hydraulic power-transmission units at predetermined temperatures. It should also include the accessory instruments for determining precisely the pertinent physical properties of the hydraulic medium under actual working conditions.

Fig. 29 of the paper presents coefficients for a nonstandard venturi meter that would raise a question as to the absolute accuracy of results obtained in this laboratory were it not for the decidedly unconventional nozzle forms used in the approach section and the lack of straightening vanes and/or other means upstream of the tube to insure normal turbulence and velocity distribution, especially at lower values of the Reynolds number. Pitot traverses are indicated. Incidentally, (1) is this Reynolds number based on the conditions at the inlet or throat of the tube? (2) Is not the coefficient of the figure actually the product of the friction coefficient (customarily used) by the correction for the approach velocity? Offhand, it would seem desirable to increase the surface roughness of the approach to the throat enough to obtain a flat coefficient over the range of Reynolds numbers shown in Fig. 14 of the paper, a modification that decreases the error due to any flow abnormality likely to occur in this installation. In this connection, it may be remarked that the spread of coefficients for a given venturi tube is generally less than for other differential producers.

Author's Closure

The author agrees with Mr. Smith that much inaccuracy in pump tests of all kinds is due to the use of Bourdon-type pressure gages. It is the author's opinion that a definite step forward will be made in the moderate-pressure and high-pressure fields by the adoption of the pressure-weighing technique in all research investigation where it is at all practicable.

Mr. Smith calls attention to the unusual calibration curve shown in Fig. 29 of the paper for the 12-in. venturi meter and states that if it were not for the decidedly unconventional construction this would throw a question on the absolute accuracy of the laboratory results. In this regard the author again wishes to point out that the venturi meters were not the primary standards of quantity measurement for the laboratory. This rôle was taken by the volumetric measuring tanks. Their accuracy is not open to question. The venturi meters were frequently calibrated in place and thus furnish reliable working standards. The Reynolds number used in Fig. 29 of the paper is based on the conditions at the throat of the tube, and the coefficient is c in the equation

$$q = cA_2 \sqrt{\left(\frac{2gh}{1 - (A_2/A_1)^2}\right)}$$

where A_2 is the cross-sectional area at the throat, sq ft; A_1 is the cross-sectional area at the upstream piezometer; h is the differential head, ft of water; q is the discharge, cfs; and c is the venturi coefficient of discharge.

In conclusion, the author would take issue with Mr. Smith's remark that the laboratory is "highly specialized." The author feels that this as a misconception of the laboratory possibilities. It is certainly true that up to the present the work has been of a highly specialized nature, but in the closing paragraphs of the paper the author tried to point out the wide scope of investigations possible in the future by means of the use of the laboratory equipment now available.

A Study of Cutting Fluids Applied to the Turning of Monel Metal[1]

Maurice Reswick.[2] In paragraph 6 of the conclusions, the authors state that the emulsion is entirely satisfactory as a cutting fluid for turning monel metal. A large portion of machine work on monel metal is done on automatic screw machines, and it has been the experience of most shops that emulsified oils produce excessive gumming which interferes with the proper operation of these machines. The use of sulphurized mineral oils on such machines is therefore a necessity, notwithstanding their tendency to stain the metal. It would be of much interest to see a curve showing the relation between cutting speed and tool life based on turning monel metal using mineral oil compounded with fats, such as lard oil, for the cutting fluid. Such cutting oils, although less efficient than sulphurized oils from the standpoint of tool life, have an advantage in that they do not stain the metal and usually produce a finer surface finish.

From former experiments performed by Professor Boston and his associates on S.A.E. 3140 steel, it appears that tool life increases progressively with the three types of cutting fluids mentioned in the following order: Mineral oil compounded with fats, soluble oils, and sulphurized mineral oils. From the standpoint of surface finish, mineral oils compounded with fats come first, sulphurized oils second, and soluble oils last. No doubt the same general conclusions apply to monel metal.

In paragraph 8 of the conclusions, referring to Fig. 6 of the paper, it is pointed out that all component cutting forces are higher when water emulsions are used as the cutting fluid than for sulphurized mineral oil, indicating that the power consumption of the machine, and therefore the heat generated at the point of

[1] Published as paper MSP-58-10, by O. W. Boston and W. W. Gilbert, in the November, 1936, issue of the A.S.M.E. Transactions.

[2] Lubrication Engineer, Standard Oil Company of New Jersey, New York, N. Y. Mem. A.S.M.E.

the tool, is greater with soluble oils. The satisfactory tool-life obtained in the tests with water emulsions is evidently due to the greater cooling action of the oil-in-water emulsion.

The criterion established by Professor Boston to evaluate the relative efficiencies of cutting fluids and machinability of metals in terms of cutting speed versus tool life is, in the writer's opinion, the closest approach yet attained in reproducing actual machine-shop conditions on a laboratory scale. As yet, however, the results of these experiments should be considered as being indicative only, since they are carried out under carefully controlled laboratory conditions, with most of the disturbing factors met in the average machine shop eliminated. Performance under actual conditions in each particular instance still remains the final proof of merit of cutting fluids.

Joseph Geschelin.[3] This paper is important not only because of its influence upon the machining of monel metal but in the broader sense because is contributes still another link in the fundamental research on the utilization of cutting fluids as well as on the design of cutting tools.

Despite the good work of the A.S.M.E. Subcommittee on Cutting Fluids, there still remains considerable work to be done in drawing attention of all metal-cutting establishments to the importance of the proper selection and utilization of cutting fluids. The larger establishments are conscious of the problem and are working on it constantly; although, even in these establishments there is room for progress.

Viewed broadly, the utilization of cutting fluids should proceed along two parallel lines—one, the immediate commercial development which must be carried on to satisfy the needs of metal-cutting establishments, and two, a definite program of fundamental research. The latter has been ably handled by Professor Boston and his associates, and it is hoped that he will be able to carry this work to a definite conclusion.

Authors' Closure

Mr. Reswick raises a question as to the proper cutting fluid for machining monel metal in an automatic screw machine. The authors stated in the paper that for the proper shape of cut, that is, a deep thin cut, an emulsion will give a higher cutting speed for a given tool life than the sulphurized mineral oil or dry cutting. Even for a comparatively shallow thick shape, the emulsions are superior to the sulphurized mineral oil when cutting at comparatively low speeds to give a tool life above 30 min. It was pointed out, however, that in turning the monel metal with a single-point tool the sulphurized mineral oil caused the chips to break up more satisfactorily, which is an advantage, but that the monel metal was stained by sulphur in the oil, which is a disadvantage.

[3] Detroit Technical Editor, Chilton Company, Detroit, Mich.

Naturally, if an automatic screw machine were to be used, presumably not only the lubrication of the machine, but in addition the types of cuts should be considered. Tapping and threading are usually done in this class of work, and the material is turned with forming tools. These are questions quite outside the scope of the paper. It would seem advisable, however, to use the sulphurized mineral oil in view of the threading, the lubrication, and the satisfactory operation of the forming tools. The authors are not in a position to furnish Mr. Reswick with an additional cutting-speed tool-life curve in which a mineral oil compounded with fats, such as lard oil, is used. As stated in the paper, there was insufficient material available to carry on more tests than those that are actually covered in the report.

Mr. Reswick raises the question as to the influence of the cutting fluid on finish, referring to results previously obtained when turning an S.A.E. 3140 steel. The authors feel that in turning cuts the finish on the work is influenced in only a small way by the cutting fluid used. Material is being accumulated along this line, and it will be the subject of a paper to be written in the near future. To secure finish, the items essential are (1) a small-size cut, (2) a tool with high rake, (3) high cutting speed, and (4) an appropriate cutting fluid. The authors believe that the cutting fluid itself has the least influence. Naturally, where low speeds are encountered, as in threading and reaming, factors other than speed become of greater importance.

Mr. Reswick has also raised the question of power versus tool life. The authors have found that, as a result of a wide variety of tests, the value of cutting force, when using a given cutting fluid, is not a satisfactory basis to predict tool life when using the same cutting fluid. In some instances it has been found that the cutting speed for a given tool life, under otherwise constant conditions, varied directly as the cutting force. That is, when the cutting force is highest for a given set of oils, the cutting speed for a given tool life is also highest. This is just the opposite of what might be expected. At the same time data are available for specific cases which show the cutting speed for a given tool life to vary inversely with the cutting force. The interrelation of finish, cutting force, and tool life is naturally of great interest to one engaged in metal-cutting operations. There appears to be no consistent relation between any two of the three. Undoubtedly, a great deal of research work still must be done to solve the riddle and thereby make it possible to predetermine cutting conditions to give the most satisfactory results.

As Mr. Geschelin points out, fundamental research and commercial practice should go hand in hand. It is believed that the commercial use of cutting fluids can be improved to a very great extent by the accumulation of fundamental data relating to the selection and application of cutting fluids.